Preparing Students for an Interdependent World: Role of Cooperation and Social Interdependence Theory

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Abstract

Tom Boyle of British Telecom describes our current era as the "age of interdependence;" former U.S. President Bill Clinton asked the question, "will interdependence be good or bad for humanity?" in his 2002 Los Angeles Times editorial; a popular business advertisement states "Collaborate or Die!;" and *The World is Flat* author Tom Friedman argues that we have to move to a more horizontal – connect and collaborate – value-creation model. If, as these pundits claim, interdependence is the current coin of the realm, then what can we do to help prepare students for an interdependent world? What are the skills and competencies that students need and how can we ensure that they gain these skills and competencies?

Several studies and initiatives – Boeing and RPI's *The Global Engineer*, NAE's *Engineer of 2020*, Purdue Future Engineer, and many others – have begun to articulate the knowledge, skills, and habits of mind that are needed. The question posed in this brief article is "What roles can cooperation and social interdependence theory play in informing the design and practice of engineering education?"

Cooperative learning and its underlying theoretical framework, social interdependence theory, have been systematically studied in engineering education for over 50 years; the first study was conducted at MIT in 1948. Engineering faculty began embracing cooperative learning shortly after it was introduced in engineering education conferences and journals in 1981 and its use continues to grow.

This paper provides a brief summary of the theory, extensive empirical evidence, and implications for practice of cooperative learning, and hopes to start a dialogue on the question, "How can we prepare students for an interdependent world?"

Introduction – State of the World

The world is changing and we are facing many global challenges, including, poverty, education, health, innovation, climate change, human rights, resource availability and utilization, etc. There is a significant rise in international collaborations around education and especially research. For example, the Large Hadron Collider at CERN (a collaboration of 20 countries) is coming online in September 2008. The Global Colloquiums on Engineering Education is one effort to bring people together to address global issues and opportunities.

The term 'global,' popularized by writers such as Thomas Friedman, shows up in many conversations about engineering and engineering education as well as in prospective outcomes

for engineering graduates. The notion of global first became clear to me and many of my generation on December 24, 1968 when Apollo 8 circumnavigated the moon. As the image of the earthrise was transmitted and showed up on TV screens around the world, CBS News Commentator Walter Cronkite said:

> I think that picture of the earthrise over the moon's horizon, that blue disk out there in space, floating alone in the darkness, the utter black of space, had the effect of impressing on all of us our loneliness out here. The fact that we seem to be the only spot where anything like humans could be living. And it, the major impression I think it made on most of us was the fact, how ridiculous it is that we have this difficulty getting along on this little lifeboat of ours floating out there in space, and the necessity of our understanding each other and of the brotherhood of humankind on this floating island of ours, made a great impression, I think, on everybody.

This was an extremely poignant and defining moment for me although I didn't recognize and fully appreciate it at the time. You can see the Cronkite segment and read more about what was described as his **A Call for Harmony on Lifeboat Earth** on the American Experience program on Apollo 8 (PBS American Experience, 2008).

Recently several world leaders, such as British Prime Minister Gordon Brown, call for global interdependence aimed at solving international problems such as terrorism, poverty, and climate change (Lavoie, 2008). During his talk at the John F. Kennedy Presidential Library and Museum in April, 2008, Brown said "We urgently need to step out of the mindset of competing interests and instead find our common interests, and we must summon up the best instincts and efforts of humanist in cooperative effort to build new international rules and institutions for the new global era." Tom Boyle of British Telecom describes our current era as the "age of interdependence" and he argues that one's Network Quotient (NQ) is more important than their IQ (Cohen & Prusak, 2001). Former U.S. President Bill Clinton asked the question, "will interdependence be good or bad for humanity?" in his 2002 *Los Angeles Times* editorial, Living in an Interdependent World (Clinton, 2001). *The World is Flat* author Tom Friedman (2007) argues that we have to move to a more horizontal – connect and collaborate – value-creation model. Friedman argues that Curiosity Quotient (CQ) plus Passion Quotient (PQ) is more important than Intelligence Quotient (IQ). John Seely Brown, former Chief Scientist of Xerox and Director of its Palo Alto Research Center (PARC) argues that social/emotional intelligence (EQ) and communication intelligence (CQ) are equally as or more important than IQ (Brown & Adler, 2008; Brown, 2008). If, as these pundits claim, interdependence is the current coin of the realm, then what can we do to help prepare students for and interdependent world? What are the skills and competencies that students need and how can we ensure that they gain these skills and competencies?

Before proceeding too far down the collaboration path, let me reassure those who argue that competition is the be all and end all that I agree there is a role for competition and we have an obligation to help develop students' skills for competing. There are several occasions where competition is the norm; sports contests, of course, are the most common, but there is also proposals and hiring. My sense is that we've emphasized competition far more than cooperation

and haven't helped students develop skills for cooperating. Buckminster Fuller argued that "cooperation is pragmatically necessary" and W. Edwards Deming (1993) made the following compelling case for the importance of cooperation and interdependence in his book *The New Economics for Industry, Government, Education.*

> We have grown up in a climate of competition between people, teams, departments, divisions, pupils, schools, universities. We have been taught by economists that competition will solve our problems. Actually, competition, we see now, is destructive. It would be better if everyone would work together as a system, with the aim for everybody to win. What we need is cooperation and transformation to a new style of management. Competition leads to loss. People pulling in opposite directions on a rope only exhaust themselves: they go nowhere. What we need is cooperation. Every example of cooperation is one of benefit and gains to them that cooperate.

The United States has been guided recently by calls for increasing competitive advantage and in this brief paper I argue for increasing emphasis on global collaborative advantage and developing the knowledge, skills, and habits of mind that support developing collaborative approaches to challenges and opportunities. The idea of global collaborative advantage was framed by Lynn and Salzman (2006, 2007) and they argue in a series of articles that we need to prepare graduates for developing global collaborative advantage. For example, Lynn and Salzman argue in their 2006 *Issues in Science and Technology article*, Collaborative Advantage, "The United States should move away from an almost certainly futile attempt to maintain dominance and toward an approach in which leadership comes from developing and brokering mutual gains among equal partners. Such 'collaborative advantage,' as we call it, comes not from self-sufficiency or maintaining a monopoly on advanced technology, but from being a valued collaborator at various levels in the international system of technology development." (p. 76). Among their three goals for the United States they argue that "the United States needs to develop a science and technology education system that teaches collaborative competencies rather than just technical knowledge and skills." Their research indicates that cross-boundary skills (working across disciplinary, organizations, cultural, and time/distance boundaries) are needed more than technical skills.

Cooperative learning and its underlying theoretical framework, social interdependence theory, can provide many insights into preparing students to work with others to synthesize common goals and then attain common purposes, which are essential for developing collaborative advantage.

Cooperative Learning and Social Interdependence Theory

Cooperative learning has been part of the landscape of engineering education for the past almost 30 years. The conceptual cooperative learning model was introduced to the engineering education community in 1981 (Smith, Johnson, & Johnson, 1981a, 1981b) and was continually refined and elaborated for engineering educators (Felder, 1995; Prince, 2004; Smith, 1995; Smith, Sheppard, Johnson, & Johnson, 2005) and higher education faculty in general (Johnson, Johnson, & Smith, 1991; Johnson, Johnson, & Smith, 1998; Johnson, Johnson, & Smith, 2000, 2006, 2007; MacGregor, Cooper, Smith, & Robinson, 2000; Millis & Cottell, 1997; Smith, 1996,

1998; Smith, Cox, & Douglas, 2008). The influence of foundational work on cooperative learning can be seen in the University of Delaware Problem Based Learning model (Allen, Duch, & Groh, 1996 ; Duch, Groh, & Allen, 2001), the SCALE-UP model at North Carolina State (Beichner, Saul, Allain, Deardorff, & Abbot, 2000), the Technology Enhanced Active Learning (TEAL) model at MIT (Dori & Belcher, 2005; Dori, et.al, 2003) and many others.

Social interdependence theory is at the heart of the cooperative learning model. In our 1981 journal of *Engineering Education* article "Structuring learning goals to meet the goals of engineering education" David and Roger Johnson and I introduced social interdependence theory to the engineering education community and elaborated on the two types of social interdependence – positive and negative – posited by Deutsch (1949a, 1962b). *Positive interdependence* exists when there is a positive correlation among individuals' goal attainments; individuals perceive that they can attain their goals if, and only if, the other individuals with whom they are cooperatively linked attain their goals. *Negative interdependence* exists when there is a negative correlation among individuals' goal achievements; individual perceive that they can obtain their goals if and only if the other individuals with who they are competitively linked fail to obtain their goals. No interdependence or individualistic efforts exist when there is no correlation among individuals' goal achievements; individuals perceive that the achievement of their goals is unrelated to the goal achievement of others.

In addition to his pioneering theory building work, Deutsch (1949b) conducted the first systematic study of cooperative learning in engineering education at MIT in 1948.

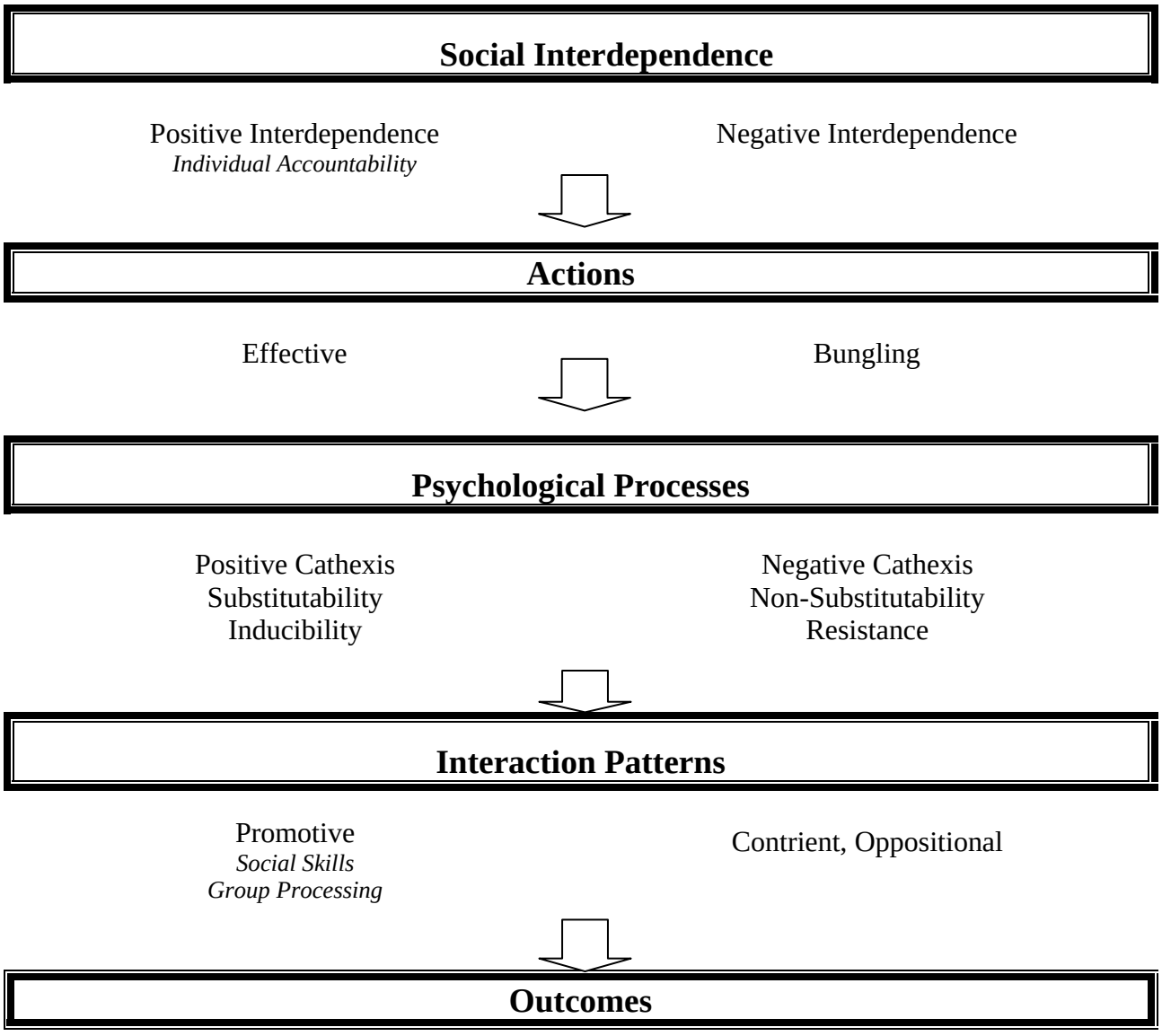
David and Roger Johnson (2005) recently summarized the state of social interdependence theory and provide excellent insight into the latest thinking. Figure 1 provides an overview of social interdependence theory.

The empirical and theoretical evidence supporting cooperative learning is vast and I'll only provide a brief summary. During the past 90 years, over 350 experimental studies have been conducted in college and adult settings comparing the effectiveness of cooperative, competitive, and individualistic efforts. These studies have been conducted by a wide variety of researchers in different decades with different learner populations, in different subject areas, and in different settings. More is known about the efficacy of cooperative learning than about lecturing, the fifty-minute class period, the use of instructional technology, or almost any other aspect of education. From this research you would expect that the more students work in cooperative learning groups the more they will learn, the better they will understand what they are learning, the easier it will be to remember what they learn, and the better they will feel about themselves, the class, and their classmates. The multiple outcomes studied can be classified into three major categories: achievement/productivity, positive relationships, and psychological health. Cooperation among students typically results in (a) higher achievement and greater productivity, (b) more caring, supportive, and committed relationships, and (c) greater psychological health, social competence, and self-esteem. Please see Smith, Sheppard, Johnson and Johnson (2005) and Johnson, Johnson & Smith (1998, 2007) for details.

Details on the key research-based elements of cooperative learning – positive interdependence, individual and group accountability, face-to-face promotive interaction, teamwork skills, and

group processing – as well as implementation of the three main types of cooperative learning – Informal Cooperative (Active) Learning, Formal Cooperative Learning and Cooperative Base Groups – are available in Smith, Sheppard, Johnson & Johnson (2005) and in extensive detail in Johnson, Johnson & Smith (2006).

Figure 1. Overview of Social Interdependence Theory



Preparing Students for an Interdependent World

Several studies – Boeing and RPI's *The Global Engineer* (Boeing, 1997), NAE's *Engineer of 2020* (2005), Purdue Future Engineer (Jamieson, 2007), *The 21st-Century Engineer* (Galloway, 2007, *Engineering for a Changing World* (Duderstadt, 2008) – have begun to articulate the knowledge, skills, and habits of mind that are needed for students to perform satisfactorily in an interdependent world. The *Global Engineer* list is especially interesting and insightful considering that it was crafted more than ten years ago.

Desired Attributes of a Global Engineer[1]

- A good grasp of engineering science fundamentals, including:
  - Mechanics and dynamics
  - Mathematics (including statistics)
  - Physical and life sciences
  - Information science/technology
- A good understanding of the design and manufacturing process (i.e., understands engineering and industrial perspective)
- A multidisciplinary, systems perspective, along with a product focus
- A basic understanding of the context in which engineering is practiced, including:
  - Customer and societal needs and concerns
  - Economics and finance
  - The environment and its protection
  - The history of technology and society
- An awareness of the boundaries of one's knowledge, along with an appreciation for other areas of knowledge and their interrelatedness with one's own expertise
- An awareness of and strong appreciation for other cultures and their diversity, their distinctiveness, and their inherent value
- A strong commitment to team work, including extensive experience with and understanding of team dynamics
- Good communication skills, including written, verbal, graphic, and listening
- High ethical standards (honesty, sense of personal and social responsibility, fairness, etc)
- An ability to think both critically and creatively, in both independent and cooperative modes
- Flexibility: the ability and willingness to adapt to rapid and/or major change
- Curiosity and the accompanying drive to learn continuously throughout one's career
- An ability to impart knowledge to others

The Carnegie Preparation for the Professions project provides several interesting parallels to our work on cooperation and civic engagement. Sullivan (2005) in his overview of professionalism in America highlights the problem of negative interdependence (p. 170) and advocates a shift of thinking toward making interdependence work through civic professionalism. Sullivan's proposed framework for renewing professional education is through three apprenticeships – the

[1]A Manifesto for Global Engineering Education, Summary Report of the ***Engineering Futures Conference***, January 22-23, 1997. The Boeing Company & Rensselaer Polytechnic Institute.

head, the hand, and the heart. The first apprenticeship, the head, focuses on intellectual or cognitive development. The second, the hand, focuses on the tacit knowledge and skills practiced by competent practitioners. The third, the heart, is focused on the values and attitudes shared by the professional community.

Engineering education stresses the first apprenticeship (intellectual development), places a little emphasis on the second (skill development), and is silent or at least not too explicit about the third apprenticeship (the heart). The third apprenticeship, which embodies what it means to be an engineer, that is the habits of mind and the modes of thinking, is crucial for preparing the 21st Century engineer. Cooperative learning is one excellent way to increase the focus on "learning to be." Later this year the Carnegie Preparation for the Professions study focused on engineering, *Educating Engineers: Designing for the Future of the Field*, is scheduled for publication (Sheppard, Macatangay, Colby & Sullivan, 2008).

Brown and Adler (2008) argue for a social view of learning where understanding is socially constructed. In contrast to the Cartesian view of learning (I think therefore I am) where knowledge is viewed as substance and pedagogy is seen as knowledge transfer, the social view of learning (we participate therefore we are) not only emphasizes "learning about" the subject matter but also "learning to be" a full participant in the field. They argue that "viewing learning as a process of joining a community of practice … allows new students to engage in "learning to be" even as they are mastering the content of the field." Furthermore, they claim that emphasizing "learning to be" encourages the practice of what John Dewey called "productive inquiry" – that is, seeking knowledge when it needed for addressing a pressing question or to accomplish a task.

Rather than provide more research findings (even those Joe Redish and I developed in "Looking beyond content: Skill development for engineers," Redish & Smith, 2008) or add more lists from august committees I'm going to provide insights from some of my heroes that I gleaned from their commencement speeches. They are summarized from the final chapter of my *Teamwork and Project Management* book (Smith & Imbrie, 2007). As I was struggling with how to close the book and provide advice on "Where to go from here" it dawned on me to listen more closely to commencement addresses and share some of that advice.

I chose two commencement addresses by Thomas Friedman, one before and one after the release of his latest book *The World Is Flat: A Brief History of the 21st Century* (Friedman, 2004, 2005). In the 2004 address at Washington University in Saint Louis he summarized the major theses of the book and commented a lot on life after September 11, 2001. He advised: "Get on with your lives." In his 2005 address at Williams College Friedman spoke about his life as a journalist and told the story of his tenth-grade journalism teacher who had a profound effect on his life. Overall his talk was organized around six lessons:

1. Do what you love.
2. Being a good listener is one of the great keys to life.
3. The most enduring skill you can bring to the workplace is the ability to learn how to learn.
4. Don't get carried away with gadgets.

5. There is a difference between skepticism and cynicism.
6. Call your parents.

Sherra Kerns is V.P. of Innovation and Research and F.W. Olin Professor of Electrical and Computer Engineering at Olin College. She was also President of the American Society for Engineering Education. Of the four commencement speakers I selected – journalist, professor, research director, entrepreneur – she is the one engineer. She states that "Your degree is your passport to a wide variety of futures, and not only those you've studied and prepared for." Here is a summary of her advice to graduates at Arizona State University (Kerns, 2004):

- Learn 100 words in five languages
- Value technological education and its intersections with business and cultural studies
- Stay awake
- And while you are awake and aware, do not be afraid
- Keep learning
- Be brave
- You can be a hero

John Seely Brown, whom I introduced earlier, is retired as Vice President for Research and Director of the Palo Alto Research Center at Xerox. His articles and books on design, information technology, learning in the digital age, and many others are scholarly and insightful. His commencement address to the Claremont Graduate University on May 15, 2004 reminded the graduates "to think differently, to listen with humility, and to proceed with openness and thought." Seely Brown has great hope for social software tools and hopes we can "transform the internet into the platform of life-long learning and social construction, so that we can understand story telling and knowledge sharing." One year later in a Commencement Speech at the University of Michigan (his alma matter) he emphasized the ability to **listen with humility**. He wrote that "This skill underlies the art of collaboration and is increasingly important as we interact with partners all over the globe. But it also underlies the art of innovation, listening not only to your customers but also to the world at large." He also highlighed the **ability to see.** He wrote, "If you want to excel in innovation, especially socially responsible innovation, then learn how to look around with unbiased eyes." (Brown, 2004, 2005).

Finally, I offer some insights from Steve Jobs' commencement advice to graduates of Stanford University. Jobs dropped out of Reed College after six months and said in his opening statement, "This is the closest I've ever gotten to a college graduation." Jobs told three stories from his life. The first was about his passion for learning what he was interested in after dropping out of college and how it influenced the design of the Macintosh computer. The second was how he got fired from Apple, the company he started, and the profound effect it had on his learning. The third was about being diagnosed with cancer and being told to prepare to die. Yes, as you can imagine, this news had a profound effect. He said, "Death is very likely the single best invention of Life. It is Life's change agent." (By the way, it turns out that Jobs had an operable form of cancer and he has recovered fully.) Jobs repeats the mantra of many commencement speakers– "You've got to find what you love." He closed with a quote from *The Whole Earth Catalog*: "Stay hungry. Stay foolish." He said that he always wished that for himself and he wishes it for the graduates. Stay hungry. Stay foolish. (Jobs, 2005).

Continual learning, flexibility and adaptability are paramount among the skills that are essential for functioning in an interdependent world. Seely Brown's emphasis on "listening with humility" is also central. Purposeful and thoughtfully structured cooperative learning groups can provide many opportunities for students to observe, model, learn, refine and practice essential skills for functioning in an interdependent world.

In closing, I return to 1962 and President John Kennedy's Global Declaration of Interdependence and his famous "moon" speech. A few months later, June 10, 1963, President Kennedy gave the commencement address at American University, in which he stated:

> "If we cannot end now our differences, at least we can help make the world safe for diversity."

We did, of course, go to the moon, but we still have lots of work to do to embrace global interdependence and to "make the world safe for diversity."

Harlan Cleveland (2002) argues that "the required solvent for civilization is respect for differences. The art is to *be different together*," and "Civilization will be built by cooperation and compassion, in a social climate in which people of different groups can deal with each other in ways that respect their cultural differences."

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