Deconstructing STEM
A Reading Through *The Postmodern Condition*

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Responses

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ABSTRACT

Since the beginning of the new millennium, educational research and policy making have increasingly involved integration of science, technology, engineering and mathematics (i.e. STEM). Integration of the four disciplines is argued to provide students with contextualized learning experiences that resemble real-life work in STEM fields, along with solutions to interdisciplinary problems that human face. In the U.S., the STEM movement has been boosted by global economic-based competition and associated fears, in terms of STEM graduates, when compared with other nations. However, many critiques question the nature and goals of this competition, as well as, the possibilities to improve STEM talents through the current conceptualizations and practices of STEM education. Through Lyotard’s (1984) conceptions of knowledge in the postmodern society, this paper analyzes some aspects of the STEM educational movement. It explores the construction of STEM discourse within competitive frames that place prime value on high performativity. There seem to be two characteristics of current STEM education that support performativity; these are an increased focus on technological and engineering designs, and a tendency for interdisciplinary education/curriculum integration. At the same time, the eagerness for performativity and competition seems to drag STEM education into selectiveness, thereby jeopardizing its possible benefits. Recommendations for educators are finally discussed.

**Keywords:** STEM; Postmodern society; Interdisciplinary education; Technology and engineering designs; Lyotard

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INTRODUCTION

Since the beginning of the new millennium, educational research and policy making have increasingly involved integration of science, technology, engineering and mathematics. Collectively, this has been called ‘STEM Education.’ STEM education has rapidly become a dominant discourse in educational, economic and political spheres. Integration of the four disciplines is strongly argued to provide students with contextualized, student-centered learning experiences that resemble real-life work in STEM fields, along with solutions to interdisciplinary problems that humans face (Tsupsos, Kohler and Hallinen, 2009). In the United State (U.S.), the STEM movement has been boosted by global economic-based competition and associated fears, in terms of STEM graduates, when compared with other nations, such as India and China (Kuenzi, 2008). Consequently, funds were allocated to support STEM education, and have translated into many educational programs and initiatives. For example, in 2009, the U.S. Department of Education allocated $4.35 billion for the ‘Race to the Top’ (RTTT) program, which has declared STEM in K-12 education as its key priority for competitive preferences between different states (U.S. Department of Education, 2009).

Through Jean-François Lyotard’s (1984) conceptions of knowledge in the postmodern society, this paper analyzes some aspects of the STEM educational movement. It explores the construction of STEM discourse within competitive frames that place prime value on high performativity. There seem to be two characteristics of current STEM education that support performativity; these are an increased focus on technological and engineering designs, and a tendency for interdisciplinary education/curriculum integration. When performing to compete economically and/or politically, STEM becomes a discourse of power: those who can ‘STEM’ better and ‘STEM’ efficiently would have the upper hand in controlling the production and consumption of knowledge, and consequently the possible futures of our world. It is highly possible that “[s]cientists, technicians, and instruments are purchased not to find truth, but to augment power” (Lyotard, 1984, p. 46). This possibility has the potential to overshadow and compromise the advantages of interdisciplinary STEM education.

THE STATUS OF KNOWLEDGE IN POSTMODERN SOCIETY

Knowledge is and will be produced in order to be sold. It is and will be consumed in order to be valorized in a new production: in both cases the goal is exchange. Knowledge ceases to be an end in itself, it loses its “use-value” (Lyotard, 1984, p. 4).

Lyotard conceptualizes the commercial status of knowledge based on one main goal of postmodern societies: to increase the efficiency of the social system. Although eagerness for efficiency may emanate from different aspirations for improvement, in postmodern society, it seems to be a translation of pressing desire to take leading roles in a competitive world. Lyotard argues that in order to achieve maximum efficiency, the system attempts to optimize performativity: to maximize output and minimize input. Hence, valued elements of societies are usually those capable of achieving this equation. Knowledge is not an exception. Valued knowledge is usually constructed from what is efficient, with probably little consideration for notions such as, rightness, equity, or sustainability. Lyotard argues that, in this realm, the main concern of research and education, by which knowledge is produced and transmitted, is to optimize performativity. Research and education would construct, legitimize and disseminate performative knowledge.

THE PERFORMATIVE SOCIETIES:
TECHNOLOGY AS A MEANS OF CONTROL

The performative societies, as envisioned by Lyotard (1984), would display two main characters: A high dependence on technology and a tendency toward interdisciplinary education. Certainly, technology enhances performativity (but not without adverse and controversial consequences); reducing time, increasing precision, and maximizing production are some examples of technological efficiency. However, for Lyotard, the essentiality of technology emanates from its role as a means of control: those who control the technological development would control the production, legitimation, and dissemination of knowledge. The type of knowledge produced and its end purposes would depend on the will of those in control of technological development. It may appear that researchers (i.e. scientists and technologists) would have the upper hand in determining technological development; however, Lyotard argues that key factor is the funds available for research, and perspectives and interests of funds providers. Indeed, scientists and technologists are just one of the actants in the complex and dynamic network of power-relations that controls the fields of science and technology (Latour, 2005). And they might not be the most effective actants. Funds available would determine what types of research are conducted, how they are used, and for what purposes. Funds shape the possibilities for research and the new technologies available to facilitate it. This financial control becomes more alarming when acknowledging the increased partnership between industries and universities to support for-profit research, regardless of adverse effects on the public interest (Mirowski, 2011). This partnership seems largely aimed at expanding private wealth by financially controlling research topics, directions, and results (Bencze, 2008). Hence, it seems that what guides technological development (and with it, research direction) is “the desire for wealth [rather] than the desire for knowledge” (Lyotard, 1984, p. 45). It is the discourse of power that controls knowledge production.

THE PERFORMATIVE SOCIETIES:
INTERDISCIPLINARY EDUCATION AND EFFICIENCY OF HUMAN CAPITAL

Another element that determines the status of knowledge is education: it legitimizes and disseminates ‘valued’ knowledge. Lyotard argues that education attempts to optimize performativity through the “slogan of interdisciplinary studies” (p. 52). Through interdisciplinary education, individuals are expected to assimilate knowledge from different sources and disciplines, and produce it in innovative ways. Learning in an interdisciplinary manner is expected to increase efficiency as it is argued to expand individuals’ expertise, improve their understanding of and attitudes toward different disciplines, and allow them to approach real life experiences (Berlin and Lee, 2005; Rennie et al., 2012). There is an array of desirable characteristics that individuals are expected to develop by learning through interdisciplinary approaches, such as, “love for learning, concern for other people, critical thinking, self-confidence, [and] commitment to democratic group processes” (Vars, 2001, p. 9). Other scholars have expanded this list and argued for interdisciplinary education that produces “functionally literate” individuals (Rennie et al., 2012, p. 14). This functional literacy includes flexibility, transferability of skills, proficiency in anticipating problems, an aptitude of doing more with less information, the capacity to improvise by making decisions without enough information, a willingness to do more and be satisfied with less, tolerance for and the ability to work and live cooperatively in the midst of diversity, change, ambiguity, uncertainty and paradox, a high level of self-direction and personal discipline, and skill in listening carefully, articulating clearly, and resolving conflicts peacefully… the capacity to consciously and deliberately create personal and collective visions of desired futures and the competencies necessary to make those future manifest (p. 14).
To a great extent, these skills and characteristics are desirable – although, depending on the context of application, some of them can be problematic. Nevertheless, many of them reflect the notion of performativity: to do the most with the least, and increase the efficiency of individuals as human capital.

Using interdisciplinary education to optimize social performativity can be problematic, especially, when performativity is about enhancing competition. When education is constructed within competitive frameworks, it becomes selective for curricular priorities and students served (Apple, 2003). This means that only knowledge that support competitive purposes would be valued, hence, represented in the curriculum. This selected knowledge would privilege individuals who have the ‘right’ cultural capitals (Bourdieu, 1983) and are capable to perform well in a competitive system. In addition, when education is about increasing performativity, any educational discourses or practices that are perceived with no operational value are usually neglected or suppressed (Lyotard, 1984). Thus, what might be achieved by interdisciplinary education, and what might be included under this slogan is largely dependent on the expected goals and the discourses that shape education.

In this section, I argued, using Lyotard’s (1984) conceptions, that knowledge in postmodern society would feature two main characteristics: a high dependence on technology as a means of control, and a tendency toward selective interdisciplinary education; that is, two features that tend to optimize performativity and support competition. In the next section, I analyze STEM education in postmodern society. I examine the nature of its competitive frameworks, and its performative features.

**STEM EDUCATION IN POSTMODERN SOCIETY**

How can STEM be read through Lyotard’s lens? First, there are influential political and economic claims that STEM is essential to take the lead in global, ‘international’, economic-based competitions. Second, to improve the quality of STEM graduates, there has been emphasis on interdisciplinary education (i.e. curriculum integration) with increased focus on technological and engineering designs. In the rest of this paper, I discuss these arguments, how they have affected STEM education, and some of their possible consequences.

**THE COMPETITIVE FRAMES OF STEM EDUCATION**

Increasing the number of qualified scientists, engineers and mathematicians has long been an urgent demand in political and industrial spheres and, subsequently, a paramount goal for educational reforms. To face international competitions, qualified workers in different STEM fields were perceived as main sources for innovation and pillars to support the economy and national security. For example, during World War I, the report *Science, the Endless Frontier* (Bush, 1945) called for improving scientific talent in order to face diseases, protect national security and improve public welfare. This report is argued to be a U.S. response to scientific competition from Germany and Japan (Zollman, 2012).

A more evocative and competitive discourse developed during the cold war. The competition with the former Soviet Union for space exploration, which is also called the Sputnik race, placed more demand for skilled STEM graduates:

The Soviet Union now has – in the combined category of scientists and engineers – a greater number than the United States. And it is producing graduates in these fields at a much faster rate. (President Eisenhower speech, as cited in Woodruff, 2013).
Improving STEM talents was perceived as an urgent issue of national security. Hence, it seems that this political-economic competition created pressure on, and support for educational reforms to improve STEM talents, which translated into several policies and adjustments of curriculum standards (Steeves et al., 2009). It could also be argued that this competitive nature has found its way into educational spaces in the form of competition over educational resources, competition to meet curriculum standards and competition over limited spots in post-secondary education.

At the beginning of the new millennium, there were general concerns – in the U.S. - regarding poor performance of pupils in STEM disciplines, continual lack of interest in pursuing STEM related careers, and insufficient knowledge and skills of subject-matter teachers (Kuenzi, 2008). Efforts to increase the quantity and quality of STEM graduates did not seem to be efficient. Although the overall historic percentages of STEM postsecondary graduates did not change - remaining at about 17% of total postsecondary degrees (Kuenzi, 2008), this situation was considered more alarming than ever. An important reason for such increasing concerns seems to be panic that U.S. is falling behind in its STEM graduates when compared with other nations, especially India and China (Kuenzi, 2008). There has been a strong emphasis, from different federal agencies (e.g. National Science Board, 2007), scientific communities (e.g. the Committee on Prospering in the Global Economy of the 21st Century (2007): Raising Above the Gathering Storm) and business organizations (e.g. Business Roundtable, 2005), that the U.S. is losing its advanced place in the global economy, and that more STEM graduates are needed in order to compete internationally. These claims have once more placed STEM education within a competitive frame reflected in different STEM education initiatives. For example, one main reform goal of the RTTT program is “to prepare students to succeed in college and the workplace and to compete in the global economy” (RMC Research Corporation, 2011, p. 2).

However, this claim of ‘international’ competition is highly questionable. There are arguments that in the contemporary environment of neoliberalism (and its hegemony over global economization and international trade agreements) (Harvey, 2005), most of the competition is between international financiers and corporations, rather than individual nations, to increase their profits (McMurtry, 2013). Education and educational policies are argued to become an indispensable means in this global network of for-profit relations (Ball, 2012), and science educational reforms tend to be constructed to increase performativity and support for-profit agendas (Carter, 2005). Hence, claims of the need for more STEM graduates is viewed as an attempt to achieve these for-profit agendas over public interest (Bencze, 2014). In fact, claims of the need for more STEM graduates are argued to be an exaggerated ‘myth’ (Stevenson, 2014). According to Stevenson, this myth aims at lowering wages of STEM workforce by increasing the influx of STEM graduates, and facilitating hiring cheap foreign STEM workforce through H-1B visas; that is, two moves that would benefit private interests of corporations and companies.

By innovation, and performativity, STEM graduates would probably make a difference in the economic competition; however, “for the benefit of who?” remains a highly contentious question. Interestingly, a study by FORBES Global 2000 about the world’s largest and most powerful companies showed a dramatic shift in power dynamic from the West to the East. This shift occurred in the last decade with China recently becoming the home of the three top-powerful companies, and Asia taking the lead of the global market (Chen, 2014). This shift resembles the international change in the percentage of STEM graduates, with U.S. losing its advanced place to India and China (Kuenzi, 2008). Thus, it could be argued that more skilled STEM graduates are needed to serve the interests of companies and corporation rather than promoting the prosperity of the nation.

This could also explain the generosity in providing funds from the industrial/business sectors to support different STEM educational initiatives. For example, to fulfill the second requirement for ‘Race to the Top’ competitive preferences, i.e. to establish cooperation between the state and STEM-capable community partners, nine out of twelve competing states developed a partnership with business/industry experts (RMC Research Corporation, 2011). Industrial and corporative STEM grants are found almost ‘everywhere’: they
focus on teacher development programs, e.g. Amgen Foundation (Amgen Foundation Grants, 2016; Teach For America, 2016); STEM youth programs, e.g. American Honda Foundation (Grants for Youth Education, 2016); schools’ curriculum standards, e.g. Chevron (Education, 2015); universities and museums, e.g. Motorola Solutions (Motorola Solutions Foundation, 2016); these are just but a few examples. The investment of industries/corporations in STEM education is undeniable and takes many forms, such as, outreach programs, college-level internships, or capstone projects (Veenstra, 2014). Most of these grants and ‘collaborative’ educational activities tend to emphasize technology and engineering education; at the post-secondary level, training the new STEM workforce seems to have become the priority of these collaborations. Hence, providing financial support to STEM education would help industries to increase their wealth by staying in control of education, and eventually of workforce composition and research direction. STEM education would then become “a moment in the circulation of capital” (Lyotard, 1984, p. 45) by which part of industries’ profit will be invested in STEM education to produce even more profit.

WHAT IS SO SPECIAL ABOUT STEM?

Constructing STEM to optimize performativity seems to have allowed two features to dominate STEM education: A tendency toward interdisciplinary education (i.e. curriculum integration), and increased focus on technological and engineering designs. At the same time, the eagerness for for-profit competitions seems to drag STEM education into selectiveness, thereby jeopardizing its possible benefits.

STEM: A discourse of interdisciplinary education and the roles of technology and engineering designs. During the twentieth century, curriculum integration became a part of many educational and research efforts. A main focus of such curriculum integration was on science and mathematics (Berlin and Lee, 2005; Hurley, 2001). However, attention to integration rapidly developed in the last three decades (particularly during the 1990s) with more focus on secondary education (Berlin and Lee, 2005). Increased focus on science and math integration is argued to be a translation of “the increased federal funding, recommendations from national reform documents, and teacher education programs related to integrated science and mathematics education” (Berlin and Lee, 2005, p. 18). While efforts for curriculum integration tended to be centered around science and mathematics, arguments to re-conceptualize relationships between science and technology were also growing more influential. Science education was criticized as being too abstract and disconnected from real-life problems. To address this concern (and others), many educators aimed at highlighting the connections between science and technology, and combining abstract knowledge with concrete applications (Pedretti and Nazir, 2011). Although, different perspectives about the relationship between science and technology existed, the dominant view perceived technology as applied science (Gardner, 1999). This perspective has been criticized as an ‘unrealistic’ reification of the dynamic, reciprocal relation between science and technology (Gardner, 1999; Roth, 2001). These different critiques and goals have contributed to re-conceptualization of the science-technology relationship and possibilities to integrate them.

It could be argued that integration of science, mathematics, and technology, and potential benefits, may have appeared as a possible means to improve STEM talents and meet the ‘urgent demands’ for efficient STEM workforce. Consequently, funds flowed to support STEM educational policies and practices; this time with increasing emphasis on technology and engineering literacy. Mark Sanders (2009) argues that the realization of critical roles played by technology and engineering in the global, competitive, world has shifted attention from ‘science and mathematics’ to STEM education: it seems that “[t]hat’s what is different about the twenty-first century, and that is why integrative STEM education is more compelling today than in decades past” (p. 25). Indeed, engineering iterative design, by which products and processes are refined through cycles of designing, testing, analyzing and troubleshooting, is argued to better prepare learners to face real-life problems (Brophy, Klein, Portsmore, and Rogers, 2008). Engineering design connects content knowledge with practical applications, and requires creativity in adapting different information, and innovation in
developing solutions (Cropley, 2015). Technology and engineering add the practicality that is highly valued in performative knowledge (with engineering design seems to be viewed as a more creative process). Hence, engineering design and technology applications seem to have become integral parts of many educational efforts. For example, it is argued that the recent Next Generation Science Standards (NGSS Lead States, 2013) represents a re-conceptualization of the relationships between science and engineering education by emphasizing engineering design and “raising [it] to the same level as scientific inquiry” (Moore, Tank, Glancy, and Kersten, 2015, p. 296). In 2014, the National Assessment of Educational Progress (NAEP) started assessing technology and engineering literacy for eighth-grade students, with plans to apply it nationwide for grades four and twelve (U.S. Department of Education, 2016). In addition, it seems that many industry-supported STEM educational programs actively focus on technology and engineering (Veenstra, 2014). It could be argued, that the pressure for competition and performativity, as they currently reveal themselves, may have allowed engineering and technology education to emerge as a prioritized necessity; a necessity to ‘put things to work’ quickly, creatively, and efficiently. Hence, STEM education seems to be a translation of the advantages of interdisciplinary education, engineering design, and technology applications, as they are constructed and framed by competition, power, and control.

**STEM: Promotion of inclusiveness and the ‘realities’ of selectiveness.** Some problematic aspects of constructing education within performative, for-profit, competitive frames, as discussed earlier, are selectiveness and exclusion: what is prioritized, supported, neglected or suppressed. STEM education is not an exception. STEM education tends to strongly promote inclusive notions, such as, STEM literacy for all, increasing women and minorities participation in STEM fields, and using learner-centered approaches to tackle real-life problems. For example, in its report, Successful K-12 STEM Education, the National Research Council (2011) articulated three main goals for STEM education in order to support “the types of intellectual capital needed for the nation’s growth and development in an increasingly science- and technology-driven world” (p. 4). These goals broadly are: (1) “to increase advanced training and careers in STEM fields”, (2) “to expand the STEM-capable workforce”, and (3) “to increase [STEM] literacy among the general public” (p. 4). In goal (1) and (2), there have been special emphases on broadening participation of women and minorities.

However, the problematic aspects of selectiveness tend to appear when examining what types of STEM literacy are expected, and what fields are included under the slogan of STEM education. For example, it has been argued that current STEM education tends to ignore environmental and socio-scientific issues (Gough, 2015; Zeidler, 2016). These issues seem to have little operational value: they are not-for-profit. Consequently, they seem to be repressed. The emphases on functional skills and knowledge, and silence about socio-scientific issues have been perceived as regression toward scientific rationalist curricula; i.e., rigidly constructed and selective curricula (Gough, 2015). Other critiques contend that current STEM literacies serve economic and societal needs for new technologies and scientific advances, but fail to prepare students for continuous learning (Zollman, 2012). Hence, it could be argued, that current conceptualizations about STEM literacy lean toward what Douglas Roberts (2007) describes as “Vision I”, by which science literacy is more disciplinary and constructed from “within science”. This stands at odds from “Vision II” that connects science literacy to social and environmental issues, and which tends to be more relevant to citizens’ everyday life (p. 730-731, emphasis in original). One might legitimately wonder how isolating STEM from their social contexts would contribute to the general public interests, and how focusing on STEM functional skills and knowledge can be more inclusive, when it has not been before.

In addition, although STEM education actively promotes the notion of interdisciplinary education, most efforts seem to focus on the four fields of science, technology, engineering and mathematics with absent voices of the arts disciplines (Zeidler, 2016). In October 2015, the STEM Education Act of 2015 became a public law (U.S. Congress, 2015). This law ‘expanded’ STEM definition to include computer science; however, with continual ignoring of other disciplines. These views and practices seem to depict the four fields of STEM as interrelating and cooperating in isolation of their cultural, social and political contexts. They unjustifiably disconnect STEM fields from the richness of other disciplines and the lenses
they may lend to address STEM related issues. The selectiveness and prioritization of particular disciplines tend to be hierarchal: some disciplines (i.e. mainly the four STEM fields) are portrayed as more important (for economic competition and national security); hence, they tend to receive more attention, funds, and efforts. ‘Othering’ non-STEM disciplines not only creates tensions regarding who is prioritized and supported, but also regarding how ‘non-STEM’ educators and teachers perceive STEM education and their roles in it. For example, in a study at the University of Cincinnati, Breiner, et al. (2012) found that most non-STEM faculty members perceived STEM negatively, and some believed that STEM is not related to their fields of work. Feeling excluded, or even threatened by current STEM discourses may render non-STEM teachers/educators reluctant to participate in STEM education initiatives, which may further contribute to the ‘unrealistic’ and unreasonable disconnection of STEM fields.

Situating STEM within social, cultural and political contexts, and relating STEM fields to non-STEM ones are crucial for both STEM workforce and the general public. STEM workforce should not only develop efficient products and services, but they should also develop moral awareness of social and environmental consequences of their work. Equally important, STEM workforce should be aware of possible power-relations that tend to affect the directions of research, education and production in STEM fields. Learning STEM as a part of complex, dynamic power-relations should also be a priority for the general public, whose everyday life is inevitably affected by them. STEM education should help the general public to use their literacy for continuous learning, and empower them to take active roles in more participatory forms of democracy (Wood, 1998). The apparent obsession with for-profit economic competition, efficiency and performativity seems to leave little space for STEM education to actualize inclusivity and citizen engagement, and to further better socio-political understanding of STEM fields.

CONCLUSION

In a study that examined a regional implementation of STEM educational policy in U.S., Carla Johnson (2012) found that different stakeholders (e.g. government, schools, private sector... etc.) showed contrasting and competing agendas and interests, which hindered the implementation of the policy. While contrasting interests may not be surprising, this draws attention to the fact that goals of many STEM educators may not necessarily intersect with those of other powerful, and probably more influential key decision makers. In addition, the promising learning possibilities made available by interdisciplinary STEM education (e.g. approaching real-life problems, preparing students for continuous learning... etc.) can be misused through a discourse of economic competition to achieve for-profits agendas. Hence, potential positive outcomes of interdisciplinary STEM education can be, and some actually are, overshadowed by desires for wealth, power and control.

Recognizing that the prominent value of STEM education, as it is currently conceptualized and practiced, resides in its ability to facilitate control to support private interests, requires development of alternative STEM discourses and practices: alternative discourses that move STEM beyond the narrow horizons of competition, and alternative practices that restructure STEM education as a means to develop a passionate and moral workforce, and to foster active citizen engagement. Facilitating the development of these alternatives, theoretically and practically, ought to be a main goal for educators. Finally, if we really aspire to “race to the top,” it is worth asking who has been left behind, what has gone unnoticed, and to what extent we have attended to social justice and environmental sustainability. To these questions, interdisciplinary STEM education must pertain.

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