Abstract
The needs of a global citizen may be determined best by educational leadership and policy stakeholders geared towards interdisciplinary Earth Science. Open-mindedness, a means to reach collective agreement, may support spatial thinking or GIS education in North Carolina towards a formal K-12 course of study implementation.

In particular, A Five-step Plan and Methodology to Introduce GIS to Educators State-wide in North Carolina conceptualized the notion of expanding spatial thinking in education. Such could anchor and lead towards a greater interdisciplinary exchange of research collaboration between secondary and K-16 stakeholders. Even the National Academy of Sciences (2006) noted the following:

Spatial thinking is not an add-on to an already crowded school curriculum, but rather a missing link across that curriculum. Integration and infusion of spatial thinking can help to achieve existing curricular objectives. Spatial thinking is another lever to enable students to achieve a deeper and more insightful understanding of subjects across the curriculum (National Academy of Sciences, 2006, p. 26).

Branch (2009) stated the following as,

As such, this work proposed that before spatial thinking and geographical information systems (GIS)/global positioning satellites (GPS) could be conveyed and implemented properly in the K-12 experience, the educational practices must be in place to address such implications and potential. In addition, as local and state governments further prepare, manage, and embrace GIS in their data operations Onsrud, Johnson, and Winnecki (1996) and; General Assembly of North Carolina (2003), public education may have to do likewise.

The need for geospatial skills was defined as a legitimate workforce concern by the Bush (2005) Presidential Initiatives warranting next generation considerations of K-12 learning. As the coordination of spatial data has been progressing since 2002, in North Carolina, an interdisciplinary approach may be the perfect catalyst to consider GIS methodology as a vital medium to support the United States Science Technology, Engineering and Mathematics (STEM) disciplines and international Group Earth Observation objectives and communities that interact with the International Panel on Climate Change (IPCC).
Keywords: Spatial thinking, GIS education, Executive Order 12906

Introduction
It should be noted that [1] Branch (2009) stated that educational community would have to have a spatial thinking paradigms and experience well understood before it could lead in such advocacy. From leadership an interdisciplinary implementation of spatial thinking and GIS education paradigms must be valued, experimented, debated and collaborated with the greater scientific community. As [2,3] Stubbs Devine and Hagevik (2000) [3] Stubbs, Devine and Hagevik advocated such ideals remains spatial thinking in the K-16 experience is largely not realized. [4] White (2005) stated that such areas need attention. The conception of GIS education is approximately 20 years old in North Carolina [1] (Branch, 2009). However, compliance to [5] Executive Order 12906 since 1994 and supporting educational paradigms are not fully implemented in the North Carolina standard course of study. Hence, such a policy status may be similar nationally as well as internationally where spatial thinking and GIS education may be critical to the international debate on climate change for the global citizen.

The [6] 2009 Obama Administration works to stimulate the STEM outcomes with the “Educate to Innovate” campaign as an afterschool experience. However, in the 1960’s, when [7] Kennedy saw Sputnik in the sky, his subsequent educational change sought a direct innovation more towards the K-12 standard course of study rather than after school enrichment activity. Moreover, scholarship has existed for decades per [5] Executive Order 12906 and especially in North Carolina from a proposed Five-step plan by [2] Devine, Stubbs and Hagevik (2000) and other state legislation. Even as the National Science Foundation Geosciences directorate works to augment geosciences outcomes, a subset of STEM disciplines, the issue of formally getting spatial thinking infusion into the K-16 standard course of study remain largely a void as suggested by [1] Branch (2009).

Thus, as [1] Branch (2009) suggested, educational change may require more open-mindedness, intentional learning and renewal towards spatial thinking. It remains an enormous political and morale task for a world faced by the uncertainty in spatial issues such as climate change and a global economy.

Statement of the Problem
The relevance of spatial thinking as an issue in educational policy has greatly increased in recent years as a result of actions taken by federal and state governments. At the federal level, the issuance of [5] Executive Order 12906, Coordinating Geographical Data Acquisition and Access: The National Spatial Data Infrastructure (Federal Geographic Data Committee, 1994), has required government agencies to manage data in a spatially aware manner. Corresponding actions have also been taken by the states.


Moreover, the legislation that established the GICC specifically mandates that the State Superintendent of Public Instruction, the elected leader of elementary and secondary education in North Carolina, participate as a member of the GICC. This plainly suggests that spatial thinking will be an important skill for those aspiring to top-level leadership roles within the state’s elementary and secondary school
systems. Yet the extent to which practicing educators currently are equipped for such roles is uncertain.

Spatial thinking refers to the use of space to describe, formulate, and solve problems, as well as to teach and conduct research. And as described by the [11] National Academy of Sciences (2006, p. 36), the basis for spatial thinking is the structure of space and the operations that we can perform on that structure.

Research Question
What aspects of educational change do participants believe must occur in order for a GIS/spatial thinking culture to reach widespread implementation? All levels of educational professionals who support GIS policy or applications in education may be considered potential study participants.

Theoretical Framework
Indeed, [12] Dewey identified communication as an important societal need: “The essential need, in other words, is the improvement of the methods and conditions of debate, discussion, and persuasion. That is the problem of the public” (Dewey, 1939). This study suggests that spatial thinking and its tools such as GIS/global positioning satellites (GPS) may be a significant improvement in the methods and conditions of debate, discussion, and persuasion. Effective use of data will change a school’s culture [13] (Sorenson and Goldsmith, 2006). [14] Dewey (1993) stated that, along with consulting the public for input, the solution to communicating with the public includes issues of natural sciences. For instance, the skilled use of a map, which is a very simple spatial tool, may be a means for government to enhance communication concerning the public interest.

Policy Implications
Hence, a geographical information system is just a data driven form of making maps for decision-making. In [5] 1994, the United States government took priority with spatial data in its infrastructure and the [15] Fifty States Initiatives is a policy movement for all fifty states to comply. The [15] Fifty States Initiative is a partnership between the National States Geographic Information Council (NSGIC) and the Federal Geographic Data Committee (FGDC). [1] Branch (2009) stated, “It is designed to bring all public and private stakeholders together in statewide GIS coordination bodies that help to form effective partnerships and lasting relationships”. Likewise, North Carolina has complied in 2002 with its GICC, while other North Carolina policies such as the [16] 1997 Leandro article 2 (North Carolina Administrative Office of the Courts, 1997), mention geography as part of a child’s right to a sound basic education.

Limitations of Study
The limitations of the [1] Branch study were most notable in the interview process, which used a small sample size drawn primarily from a single region within the state of North Carolina. And although all interviews followed the same protocol and posed the same questions, difficulties in scheduling necessitated that some interviews be conducted by phone or email, as opposed to the preferred in-person format. Finally, the exclusive reliance on interview data and the absence of data against which the participants' statements might be triangulated must be acknowledged as a significant limitation.

Interdisciplinary Best Practice
Obstacles to the progression towards the compliance of spatial thinking and GIS education formal paradigms in education may be a combination of awareness, leadership focus and visionary transformative values by the greater society. Certainly, [1] Branch (2009) indicated that “spatial thinking is not on the radar of educational leadership”. Even, with state policy directing such influence, a partial acceptance has on been fully validated in the [1] transportation aspects of education in North Carolina but ironically seldom formalized in other parts of North Carolina educational development.
Branch (2009) clearly indicated that educational leadership must be spatial thinkers before they can require, assess or promote such formally in education. Obstacles to interdisciplinary approach may be formally considered as tenure constraints as discipline may not actually value interdisciplinary research of which spatial thinking may be best centered as a medium.

**Plausible Approaches Compromises**

Systemic educational change may be the best approach to interdisciplinary spatial thinking paradigms. Branch (2009) noted the following:

All aspects of education should consider their own experiences as being correlated to issues of time and space because a major Science Technology Engineering and Mathematics (STEM) policy actor, such as the National Academy of Sciences, has done so. Therefore we need to invest in a systematic educational program to foster spatial literacy by enhancing levels of spatial thinking in K–12 students (National Academy of Sciences, 2006, p. 22). Such activity by a major policy maker like the National Academy of Sciences (2006) may influence educational change.

**Conclusions**

The themes that emerged from Branch (2009) findings were public interest, administrative capacity, classroom use, and, policy and research. These findings address the aspects of educational change sought in the study’s research question: What aspects of educational change do participants believe must occur in order for a GIS/spatial thinking culture to reach widespread implementation?

One major finding was the following from Branch (2009):

A spatial thinking policy has been present twenty-five years in formal policy past for the North Carolina Department of Public Instruction’s (DPI) Transportation Division. (See for example, North Carolina Public School Law– pupil transportation 115C-240 sub-section d) This illustrates the administrative capacity and policy themes emerging from this research. Yet, this has not evolved into spatial thinking content within the state’s Standard Course of Study. Such emanated as a consideration for educational renewal. Perhaps, it a plausible to take successful spatial thinking implementation from North Carolina transportations area as applicable to incite similar frameworks throughout on a state educational level where the power of spatial thinking can be verified in terms of effectiveness and levels of service. Here, should be the anchor of interdisciplinary GIS educational collaboration in North Carolina.

**global interdisciplinary collaborations**

Perhaps, the interdisciplinary challenge of adding spatial thinking or GIS education formally to North Carolina K-16 standards remains a simple compliance towards spatial federal and state policies where cost effective professional development may be necessary. Perhaps, a low cost cross-disciplinary research among Earth Sciences and educators should lead to formal teaching certifications for the geosciences discipline. For without such being recognize, to have a skill without a job may not be desirable or sustainable for the geospatial workforce demand, STEM outcomes or building international synergy for Group Earth Observation and International Panel on Climate Change policy formulation.

A global competitive education may benefit from more focus on Earth Science. Such, may be necessary for the future global citizen. Moreover, a green economy may need a K-16 system that fosters new thought paradigms to make the next generation globally competitive. For instance, the Group Earth Observation organization in 77 countries punctuates the value of spatial thinking in tools of remote sensing, GIS and Earth Science and vital tools of climate change examination and world policy collaboration. If 77 countries can agree then certainly a state educational agency can
summarize the value of spatial thinking formally in its curriculum.

Moreover, in the United States, as neighbor Virginia is experimenting with its GIS initiative in middle school and high school experiences, certainly North Carolina can take the suggested 5 step plan to new height of involvement. In particular should be note that The North Carolina educational transportation system is totally based on spatial thinking paradigms of GIS for the last 20 years. Such a proven value and state laws should be transferable throughout educational paradigms.

implications for educational change
Certainly, education should advance citizenry towards recognizing and taking advantage of policy, technology, and innovation that benefits society. Greater acceptance, awareness, and implementation of spatial thinking are the targeted goals of this study. Change in the philosophy and practice of education is vital to achieving optimal problem examination and decision-making because school issues change over time. A plausible resulting effect will be a more enhanced engagement in the public interest, administrative capacity, classroom use, and policy and research aspects of education.

Future Research
Despite these shortcomings, this study contributes to the as yet sparse literature on the role of spatial thinking in contemporary elementary and secondary education. It does so by soliciting ideas from varied practitioners and policy-makers in this field and highlights the significance of certain developments, including [5 ] Executive Order 12906 and the Fifty States Initiatives (National States Geographic Information Council, 2009), which seeks compliance with spatial management data by state agencies. The [15] Fifty States Initiative is a partnership between the National States Geographic Information Council (NSGIC) and the Federal Geographic Data Committee (FGDC). It is designed to bring all public and private stakeholders together in statewide GIS coordination bodies that help to form effective partnerships and lasting relationships (National States Geographic Information Council, 2009).

One avenue for future research, therefore, would be broader, more intensive analyses of the possible impact of these initiatives on both classroom practice and decision making in local school systems. Future research may confirm the study's theory implications and define further consequences of a spatial thinking experience throughout educational functions. The work of [18] Taylor, Vasu, and Causby (1999) benchmarked GIS use by superintendents in 10 counties in North Carolina should be further investigated with this study's finding of a perception stating that GIS use was currently involved in nearly 100 North Carolina counties by study participant 23 (interview, August 22, 2007). More work to correlate the use of data-driven GIS tools to the superintendent retention rates should be explored further as referenced by [18] Taylor, Vasu, and Causby (1999).

References


