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# Teaching Spatial Thinking from Interdisciplinary Perspectives Workshop

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**Abstract.** The Teaching Spatial Thinking from Interdisciplinary Perspectives (TSTIP) workshop was held at COSIT 2015 in New Mexico, NM. The objective of the workshop was to bring together researchers from a diverse set of fields to address the issue of how to best promote teaching spatial thinking topics from interdisciplinary perspectives. The TSTIP workshop was one project that came out of the TSTIP Initiative, which seeks to promote teaching spatial thinking topics from interdisciplinary perspectives. This short paper introduces the TSTIP Initiative and its projects.

## 1 Introduction to the TSTIP Initiative

Spatial thinking is thinking or reasoning that involves the location and movement of objects and/or ourselves, either mentally or physically, in space. Spatial thinking includes a wide range of concepts, tools, and processes (National Research Council, 2006). Unfortunately, spatial thinking is often taken for granted in our everyday lives because it's all around us – it's so ubiquitous to our experience in the world.

Just as spatial thinking can be found throughout our everyday lives, so it can also be found throughout academic disciplines and fields. Science, technology, engineering, and math (STEM) fields all require spatial thinking, and creative fields, such as, architecture and art, also require spatial thinking. Spatial thinking can be found within these fields by looking for the use of spatial properties (e.g., location, distance, direction, shape, motion, composition, and transformation) in completing a task or solving a problem. Using the idea of spatial properties, we can see that spatial thinking can be found throughout STEM fields: Chemists use spatial thinking to understand the three-dimensional structure of atoms; while, Engineers use spatial thinking to calculate the forces placed upon a vehicle during a collision, and so on. But that spatial thinking is also found throughout the creative fields: Architects use spatial thinking when trying to maximize space utilization through the arrangement of walls, hallways, and staircases. Artists must consider how individual elements will contribute to the overall composition of their artwork.

Spatial thinking is not just important within separate disciplines; spatial thinking spans and connects numerous disciplines. For example, a psychologist might research how individuals use spatial thinking strategies to find their way in a neighborhood. A cartographer might research how best to convey the spatial properties of an environment on a map. But if the psychologist and the cartographer never interact and never learn about each other's work, then how can we be sure that the spatial properties of the map can interact with the spatial thinking abilities of its readers?

Since many disciplines and perspectives both draw upon spatial thinking and also contribute to our understanding of spatial thinking, research around spatial thinking is inherently interdisciplinary. Interdisciplinary research requires interdisciplinary courses, at the undergraduate and graduate levels, to teach students how to investigate spatial thinking from multiple perspectives. However, developing course material outside of one's discipline can be particularly challenging for educators, and these challenges can restrict the perspectives taught within a single course. How can we bridge the gap across disciplines to research, study, and learn about spatial thinking?

The Teaching Spatial Thinking from Interdisciplinary Perspectives (TSTIP) initiative was developed to address this issue of how to best promote teaching spatial thinking topics from interdisciplinary perspectives. The TSTIP initiative's goal was to connect researchers and educators in fields related to spatial thinking, and gather or develop educational materials that could assist educators with teaching spatial thinking from interdisciplinary perspectives. This is essential in the era of online learning where readily available materials are blended with intensive face-to-face sessions (i.e. flipped class room). Towards this end, three projects were developed and implemented: 1) crowd-sourcing educational materials; 2) developing in-person workshops and/or symposiums; and 3) establishing an educational resource repository. Each of these projects will be discussed in turn.

## **2 Crowd-Sourced Educational Materials**

We set out to crowd-source a list of educational materials, readings, and resources – all related to how different disciplines conceptualized spatial cognition and/or spatial thinking – and to use these resources to develop an online repository for educators. To this end, we invited experts from a range of disciplines to provide their syllabi and/or reading lists for undergraduate and graduate courses, or introductory readings for graduate students. These experts were contacted via email and email lists for spatial cognition and spatial thinking researchers. We received 25 syllabi and reading lists from 12 individuals within a varied set of disciplines. Unfortunately, there were large gaps materials provided, such as, missing entire disciplines and perspectives related to spatial thinking. In the end, our crowd-sourcing efforts did not provide enough materials to establish the development of the online repository.

### 3 In-Person Workshops and Symposiums

In order to garner awareness of and interest in the TSTIP initiative, we decided to develop workshops and/or symposiums co-located with major conferences. The goal of these workshops and symposiums would be to gather researchers and educators from a wide range of perspectives and disciplines that involve spatial thinking. They could share their expertise in a spatial thinking field, and acquire new perspectives on spatial thinking from experts in other fields. At the end of the workshop or symposium, all the participants would leave with new perspectives, resources, tools, and connections that would aid them with teaching undergraduate and graduate courses in spatial thinking.

**Workshop Participants.** These workshops would be relevant for: 1) Junior faculty or researcher, such as post-docs and graduate students, who might teach a course in spatial thinking in the near future. 2) Experienced faculty, who might already teach a course in spatial thinking, but who are interested in expanding the perspectives from which they teach their spatial thinking course(s). 3) Educators of undergraduate and/or graduate courses in spatial thinking.

**Workshop Topics & Discussion.** At the workshops, experts would share how spatial thinking is approached within their field, such as: major topics and findings, recommended readings and educational resources, and future directions within their field. These presentations will be given from the perspective of assisting a workshop attendee, who is unfamiliar with the invited speaker's field, with gaining familiarity with the field so that the workshop attendee can teach a course that includes perspectives from the invited speakers' field.

**Collecting Education Resources for a Repository.** During the workshop, educational resources (e.g., spatial thinking topics within each discipline, educational resources/tools/recommendations, and/or recommended readings) would be collected from workshop attendees and made available in a repository. After the workshop, the educational resource repository will be made freely available online so that educators can use the materials to develop their own interdisciplinary spatial thinking courses.

### 4 Educational Resource Repository

Developing an online repository was a priority for the TSTIP initiative because it would allow educators from various fields to both contribute to and benefit from educational resources for teaching spatial thinking topics. In order to provide the greatest range of educator resources, the repository was conceptualized as a hierarchy of disciplines, spatial thinking topics, and then educational resources.

In addition to a list of disciplines related to spatial thinking, we wanted to provide an overview of each discipline's approach to spatial thinking. Within each discipline would be a list and overview of spatial topics. Within in spatial topic would be

educational resources, such as, recommended academic papers and books, as well as educational readings, activities, homework assignments, discussion topics, etc. These materials could be specific to one field, or could be interdisciplinary in nature, but all materials should be accessible to educators outside the field of interest. This way, any educator could use the materials to incorporate perspectives about spatial thinking that were outside of their area of expertise. Interdisciplinary educational resources should be cross-listed under multiple disciplines and/or topics, as necessary.

Once the repository is fully developed, we wanted to expand the repository to include interdisciplinary spatial thinking at all levels of education, from grade school to graduate school. Evidence is mounting that improving spatial thinking in grade school can increase the number of individuals pursuing careers in STEM fields and support educational attainment in STEM fields (e.g., Newcombe, 2010). So by providing educational assessments, readings, activities, etc. around spatial thinking for children and teenagers, we could potentially contribute to these students pursuing post-secondary education in STEM fields.

## **5 TSTIP Workshop at COSIT 2015**

**Workshop Overview.** The "Teaching Spatial Thinking from Interdisciplinary Perspectives" workshop, located at the COSIT 2015 conference in Santa Fe, New Mexico, was developed to address the issue of how to best promote teaching spatial thinking topics from interdisciplinary perspectives. This day long workshop's goals were to: 1) Assist educators in developing interdisciplinary courses on spatial thinking; and, 2) Develop a repository of educational materials that educators could use to create interdisciplinary courses on spatial thinking. To address these goals, the workshop was composed of four major elements: invited talks, lightning talks, group discussions, and educational resources collected for the online repository. Each of these will be discussed in turn.

Invited speakers from four disciplines – Psychology, Geography/GIScience, Informatics, and Neuroscience – provided an overview of the major topics, major findings, recommended educational resources, and future directions of their field, with respect to spatial thinking.

Workshop participants were invited to submit short papers discussing spatial thinking from their discipline(s) perspectives. Five of these papers were selected for lightning talks.

During the workshop, group discussions allowed for individuals from different fields to discuss spatial thinking and how to best develop interdisciplinary courses on spatial thinking. These discussions allowed workshop attendees to learn more about discipline(s) that they were unfamiliar with, and to share educational resources from their own discipline(s).

Before and after the workshop, educational resources (e.g., list of topics and subtopics within each discipline, educational materials, and recommended readings) were collected from workshop attendees, included on the workshop website, and will be placed into an online repository of interdisciplinary educational materials. After the workshop, this repository will be made freely available online so that educators could create their own interdisciplinary spatial thinking courses.

There were three main outcomes of the TSTIP workshop: 1) the workshop proceedings, 2) workshop presentations available online, and, 3) a prospective partnership for developing the educational repository. Each will be discussed in turn.

**Workshop Proceedings.** Invited speakers and lightning talk speakers contributed to the workshop proceedings, of which this paper is the first chapter. Included in the workshop proceedings are perspectives from architects, mathematicians, computer scientists, geographers, GIScientists, geoinformatics experts, and psychologists.

**Workshop Presentations.** Some of the invited speakers and lightning talk speakers allowed their presentation slides to be shared. The presentations are on the LinkedScience.org website at <http://linkedscience.org/events/spatialthinking2015/>

**Educational Repository.** The TSTIP Initiative is currently investigating the possibility of collaborating with GEOTHNK to develop the educational repository. GEOTHNK (<http://www.geothnk.eu>) is an initiative to bring together European organizations to develop a framework of novel learning pathways that span the traditional educational sectors and informal learning spaces by effectively using open educational resources and practices. GEOTHNK is a part of the Open Discovery Space (ODS), which is a multilingual platform for sharing online learning resources.

## 6 Conclusion

Spatial thinking spans and connects numerous disciplines; therefore, the TSTIP initiative seeks to provide resources for connecting these disciplines in the classroom. Using crowdsourcing of educational materials, in-person workshops and/or symposiums, and by developing an educational repository, the TSTIP initiative is bringing together experts in spatial thinking to provide resources for educators.

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