ISPRS 3S-4-schools final report

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Introduction

Spatial information sciences are ubiquitous; location-based services permeate everyday life. The science behind the handy smartphone apps that provide real-time services for billions of users, however, are not commonly known. Hundreds of years ago, the best scientists and mathematicians worked, or at least dabbled, in geodesy; nowadays, this domain is hidden behind a wall of obscurity. Outsiders typically regard the geosciences and geography as marginal, and as less relevant than other, non-spatial fields.

Learning about spatial relationships is important for every age group, but an age-appropriate education can benefit development processes in many areas. “Finding your way” around life should be an educational goal for parents and schools; spatial understanding is the basis for this essential skill that gets us from where we are to where we want to be, safely and on time.

ISPRS 3S-4-schools project aims at improving understanding of advanced concepts in remote sensing and global satellite navigation. To that end, we have developed age appropriate modules available to help youngsters understand basic ideas behind the geosciences. These basics are the building blocks for advanced concepts in the technologies that we use every day. We start with the simplest concepts: left-right and forward-behind, in contrast to north-south in way finding descriptions.

The development of spatial understanding and mental mapping in younger kids is still an under-examined issue in development psychology. It is, however, necessary to teach these skills systematically, especially in the modern ‘cloud’ and ‘spatially independent’ internet society, where spatial education and outdoor experience are lacking.

The ISPRS 3S-4-schools project enlists graduate students of Wuhan University to teach youngsters, and by teaching core concepts at the most fundamental level will improve their

understanding of the discipline; thereby gaining valuable experience in teaching and project management.

Progress Report

Instead of a final report, we are going to give a progress report, as the project is not finished, yet. We experienced a couple of unexpected problems in the implementation of the project. However, in the course of overcoming these obstacles, we believe that we improved the project and the teaching content and taking it a step further.

Gatekeepers

The main problem that we faced was, partly due to our naivety, the underestimation of the role of gatekeepers. In presenting our ideas to teachers, we typically got good feedback and invitations to conduct our research and work on the project. However, administrative and head teachers often function as gatekeepers and are much more difficult to convince.

In the beginning, we were frustrated. It took us time to understand the viewpoint of gatekeepers and learn to speak their language using the right terminology to express our ideas. However, in hindsight we found that the concerns were well founded and that through the discussions we finally improved our approach.

Major Problems

First, we wanted to have a flexible approach and discuss the contents of our program with the teachers to fit well into the current teaching plan. This approach, however, did not work at all. Teachers and headmasters preferred or demanded a clear content and a finished teaching plan before even discussing collaborations. This forced us to develop teaching plans first, which massively delayed our project.

Second, in the beginning we aimed mainly at older high school students. However, at least in China, for this age group it is very difficult for outsiders to access. Teachers and headmasters are focused on scores and exams at this time, while more time for experimental teaching and additional content is available for pupils at a younger age. We therefore decided to focus on younger students first, to develop a portfolio of teaching modules that will then help us in convincing the gatekeepers, like headmasters, for teaching older students.

Third, due to the delay in the beginning, our project suffered from loss of motivation of our supporting student team. The participation shrunk down to a core team of just a handful of

members. Although this is not ideal, with a smaller team is now easier to develop teaching plans and modules that are more coherent and integrated together as a program.

Adjustments and first experiences

In the beginning, we started by talking with teachers and administrators about the project, to find supporters. That worked well, but at the same time, these gate keepers did not provide us with the results we were expecting. Administrators especially were hesitant and wanted to see a finished teaching concept, while our idea was to develop such concept in cooperation with the school according to their needs and suggestions. We discussed, but it sometimes seemed as if we were talking different languages. It took us a while to understand the needs of the schools.

So, it became clear, that we had to develop a framework and a teaching plan and offer a complete package, before we even can start discussing this project with gate keepers. It also became apparent, that we need to include validation concepts, and research on the spatial concepts of kids of different ages and their understanding of abstract symbols.

Figure 1. Teaching at Beijing RiTan Elementary School on November 12, 2018

In a first teaching example in Beijing at the Beijing RiTan Elementary school, we also got a bit more critical in our self-evaluation. Although the kids liked it, the feeling of not teaching them spatial concepts nagged us and we did overthrow our previous concepts and therefore our project proposal. Instead, we developed a new teaching plan altogether.

In doing so, the previous reservations from administrators and teachers did make sense. It is actually hard to define age-appropriate teaching goals; we were forced to strip down to the real basics of spatial thinking. In retrospective, this was very rewarding work and we are happy with what our students in the ISPRS-3S-4 schools team designed.

Figure 2. Teaching test for the new concept on January 24,2019

However, this process took a long time and is on-going, so that we are far exceeding our previously estimated time frame. We believe that this delay is justified, especially in light of what we achieved and the changes the proposed project underwent. Our first test of the new concept in January 24, 2019, proved to be successful, but is still not ready without further refinement of the material and the teaching approach.

In the following section, we show the teaching modules that have been developed until now and that are becoming ready.

Concepts

The program is divided into several teaching modules. In theory, each module stands on its own, although they build on each other. The modules are normally 20 minutes long and can be combined, depending on the needs of the teachers and the school.

Additionally, there are creativity and experimental modules. These serve as basis for on-going research and testing to assess progress in spatial understanding, and to evaluate the pedagogy.

Module Teaching Plan

Class/Age: 0-3rd grade

Topic: Spatial Thinking and Directions

Teaching Goals:

Differences in spatial concepts of personal directions (left/right) against cardinal directions (North-South-East-West), introducing the concept of direction using the sun and compass. Explaining the use of special words for directions and learning the meaning of these words.

Teaching Methods:

Students moving according to the teacher's instructions forward, to the left, right, etc.
Learning from the resulting chaos that left & right are not always suitable descriptions
Discussion on sun ascending and descending directions
Hands-on experience with a compass

Time	Goal	Content
0:00 – 0:10 (10 min)	Directions with left/right	• Game / standing up • Follow instructions left/right • Facing different directions • Chaos ;) • Explain students why we use special words to tell direction
0:10-0:15 (5 min)	Sun ascending direction for East and West	• Discuss with students where the sun goes up and goes down • Mark these locations in the classroom with huge East and West stickers • Identify North and South accordingly
0:15-0:20 (5 min)	Compass introduction	• Introduce compass • Explain compass
0:20-0:25 (5 min)	Compass Hands-on	• Students find directions with a compass • Students control If the markings in the class-room are correct

Module Teaching Plan

Class/Age: 0-3rd grade

Topic: Basic Symbols

Teaching Goals:

Maps represent objects in abstract symbols. Such abstract symbolism can be challenging in map understanding, especially for younger kids, the concept of abstract symbols as well as some typical map symbols are explained.

Additional activities in group work and on problem-solving skills.

Teaching Methods:

Presentation and handouts illustrating different symbols and applications
Group game with symbols
Individual work / painting

Time	Goal	Content
0:00 – 0:10 (10 min)	Basic Symbols	• Introduction into symbols • Presentation of everyday symbols
0:10-0:15 (5 min)	Map Symbols	• Showing map symbols • Explaining symbols and their relation to real world objects • Give various examples
0:15-0:20 (5 min)	Group Game	• We play a game in guessing the meaning of symbols

Module Teaching Plan

Class/Age: 3rd-4th grade

Topic: Working with Maps

Teaching Goals:

To work with maps, we show the difference between photos and maps. Maps and their orientation with the help of a compass are shown.

Distances and their representation in a map are shown. The principle of a circle as a function of identical distance is demonstrated and experienced. Finally, students are about to draw maps or spatial representations by themselves.

Additional activities in group work and on problem-solving skills.

Teaching Methods:

Presentation and handouts.
Hands-on experience with maps and orientation of maps
Group work for determining distances in maps

Time	Goal	Content
0:00 – 0:05 (5 min)	Difference photos and maps	• Aerial images • Orthophotos • Maps
0:05-0:15 (10 min)	Map orientation	• Hand-out maps • Orientation of maps with a compass • Determining the own location
0:15-0:25 (10 min)	Group work	• Determining distances in a map • Cutting scale from paper • Using scale as ruler • Introduction circles for same distance

Module Teaching Plan

Class/Age: 4th–5th grade

Topic: Principles of Geometry for understanding GPS

Teaching Goals:

Introduction of the basic geometric elements—points, lines, and shapes. Teaching geometry with intersecting circles; basic elements of GPS, spatial sciences, and geometry.

Additional activities in group work and on problem-solving skills.

Teaching Methods:

Getting students interested in the topic via the GPS application.
Coming from space-science down to basic elements but keeping students interested
Active participation and learning from doing / grasping

Time	Goal	Content
0:00 – 0:10 (10 min)	Introduction and GPS basics	• Introduction into GPS / smartphone • Demonstration of satellites and launches • Explain satellite positioning and introduce the concepts
0:10-0:15 (5 min)	Group work preparation	• Separate the class in groups • Assign each group a “satellite position” a point • Assign each group a distance • Let the group cut the rope of a certain distance
0:15-0:25 (10 min)	Group work	• Satellites draw circles • Student on chair holding rope, students on the floor form the ‘human circles’ by walking • Where students from groups meet – positions / circle intersections

Module Teaching Plan

Class/Age: Highschool
Topic: Finding your dream

Teaching Goals:

Presenting the students with applications of the content taught in school linked to ideas about future study / career choices within the spatial information sciences. As an interdisciplinary topic, the spatial information sciences touch upon a wide field of school subjects with a range of applications, many of them are hidden in everyday interactions with today's smart phones or the spatial science infrastructures forming the backbone of our future; for example, self-driving cars.

Teaching Methods:

Showing everyday applications of Math, Physics, Geo-Sciences, etc. hidden in our modern life behind smart phones.
Demonstrate the importance of English language and cultural education for university education

Time	Goal	Content
0:00 – 0:15 (15 min)	Introduction into GPS and mapping	• Introduction into GPS – demonstrating the use of triangulation, geometry, and physics to find positions • Mapping and visualization – based on Math and also used in computer games
0:15-0:25 (10 min)	Remote Sensing of climate change	• Introducing Remote Sensing and the underlying methods of Math and Physics • Showing applications for climate change within the context of Geography and Biology
0:25-0:35 (10 min)	English for research	• Demonstrate the importance of English for university education • Discuss the importance of a well-rounded education also for STEM research
0:35-0:45 (10 min)	Discussion	• Open Discussion with questions

Module Teaching Plan

Class/Age: all grades

Topic: Going to School – An intercultural discussion on schools in their environment

Teaching Goals:

Intercultural understanding and learning about the schools and environments in under countries based on first-hand experience from the teachers (PhD students).

Teaching Methods:

Interactive presentations

Time	Goal	Content
0:00 – 0:05 (5 min)	Introduction	• Introduction into the content • Presentation of the teachers
0:05-0:15 (10 min)	Country 1	• The country is presented • Schools are shown • Problems of schools are described
0:15-0:25 (10 min)	Country 2	• The country is presented • Schools are shown • Problems of schools are described

Creativity Module Plan

Topic: Basic Mapping

Teaching Goals:

Students use the previously learned content to design their own maps. By establishing limits through map design requirements and the freedom of creating their own map, a creative process is enforced.

Teaching Methods:

Students work independently. Creativity is promoted by giving youngsters the freedom to draw within the constraints of a map.

Time	Goal	Content
0:00 – 0:05 (5 min)	Introduction	• Introduction into the work • Handing out of the paper
0:05-0:20 (15 min)	Student work	• After discussing maps and their function, students are about to draw two maps: A map of the classroom (can currently see) and a map/representation of their way from home to school (mental map)

Creativity Module Plan

Topic: Abstract Symbols

Teaching Goals:

Students use the previously learned content to design their own map symbols. By establishing limits through map design requirements and the freedom of creating their own map, a creative process is enforced. This module encourages abstract thinking.

Teaching Methods:

Students work independently. Creativity is promoted by giving students the freedom to draw within the design constraints of a map.

Time	Goal	Content
0:00 – 0:05 (5 min)	Introduction	• Introduction into the work • Handing out of the paper
0:05-0:20 (15 min)	Student work	• After discussing map symbols and their function, students are about to draw their own map symbols. Some symbols are mandatory, e.g. a symbol for a school, while we let students also design symbols for things that should be on a map

Outdoor Module Teaching Plan

Topic: Finding your way

Teaching Goals:

Use the learned map basics in the real environment. Students learn by working in groups and orient themselves in an outdoor environment with minimal influence from teachers / parents.

Teaching Methods:

Project based group work

Time	Goal	Content
0:00 – 0:10 (10 min)	Introduction	• Describe the task / game (geo-caching / treasure hunt) • Separate in groups
0:10-0:20 (10 min)	Preparation	• Prepare materials • Hand-out description • Get ready
0:20-0:?? (tbd)	Treasure Hunt	• Students go out in groups to find the treasures marked on map. The groups find the same treasures, but in a different / random order

Research plan

To validate our results and to work on a better understanding of the spatial mental mapping of kids in different age groups, we work on different research ideas. Our research is hereby focusing on the development of spatial understanding as well as the understanding of abstract symbolism in young ages. These are important to improve the age appropriate teaching plans to fit into the development stage. Teaching spatial concepts need to work with the spatial understanding; maps are, on the other hand, incomprehensible without a concept of abstract symbolism.

The on-going research is working on these two points. After the courses, kids get to develop and paint their own symbols or paint a mental map about their way to school, depending on the age group. This work is to a) validate basic teaching success and b) to analyze the overall capability of the kids in mapping and abstract symbolism, putting into the wider context of the school / kindergarten the data was collected.

Our current hypothesis is that certain educational forms are more effective at fostering the creativity and abstract thinking required for creating abstract symbols and maps. We therefore expect those approaches will stimulate students to produce more abstract symbols and maps, probably with stronger expressions of spatial relationships, in contrast to ‘picture maps’ or concrete symbols we expect as results from groups that are less capable of abstract thinking.

This process is supported by video taking and interviewing of students to get a description of their thinking process and explanations on the meaning of the symbols and maps, to better judge the creativity and spatial context of the results.

Video is also important for validating the teaching process. As expect to only get a limited amount of content across, and due to a lack of possibility to test that after a defined time period, we decided to measure our teaching ‘success’ by levels of engagement of students. That is to say, we define an engaged class with good student-teacher connection to be successful.

Here the videos from different viewpoints are essential to capture and later quantify the levels of engagement of the class and to improve content and teaching methods to improve that. It is clear, that engagement is not identical to teaching success, but we consider it a good and measurable result in terms of the initial goals of the project, which is informing and inspire students of different ages for spatial information sciences.

Publications

J.S. Tao, S.C. McClure, X.X. Zhang, M. Waqas, X.S. Wen, “A scientific writing pedagogy and mixed methods assessment for engineering education using open-coding and multi-dimensional scaling,” *International Journal of Technology and Design Education*, 2019 (in press, available online)

Budget 2018 – 2019

2018-06-15	**Funding received (at Wuhan University)**	**25.494,80 RMB**	**4000,00 CHF**
2018-06-15	Wuhan University management fee	764,84 RMB	120,00 CHF
2018-06-15	LIESMARS management fee	2039,59 RMB	320,00 CHF
2018-12-29	Camera – Sony HDR-CX680	3299,00 RMB	517,60 CHF
	Overall	**6103.43 RMB**	**957,60 CHF**