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# A model for improving spatial thinking in undergraduate modules with a spatial focus offered by Geography departments at selected South African universities

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**Abstract:**

We live in an era of super complexity, and a fresh look at Geography, Geographical Information Science (GIS), Cartography and Remote Sensing curricula is needed. Although Geography has been described as a science with 'secret powers' that could potentially save the world, this notion could be expanded to include related modules such as GIS, Cartography, Mapwork and Remote Sensing (collectively referred to as spatial modules in this research). These 'secret powers' that could potentially save the world refer to geographic, geospatial, and spatial thinking. Spatial thinking is a vast and ubiquitous skill and forms the focus of this research. It can be reasoned that spatial thinking should be accorded the same level of interest in education as reading, writing and computational reasoning. In the case of teaching spatial modules, more emphasis should specifically be placed on spatial thinking than on the other mentioned skills. Spatial modules are suitable for the development of the spatial thinking skills of undergraduate students. Should spatial thinking be overlooked in the curricula of these modules, the key ways in which the brain comprehends and organizes information will be neglected.

A desktop study and related research conducted by the authors indicated that the inclusion of spatial thinking in the curricula of undergraduate spatial modules in South Africa is limited. The benefits of having well-developed spatial thinking skills are numerous. A person with such skills should be able to understand the spatial relationships among different phenomena, analyze these relationships, assess the quality of spatial data, use spatiality as a way of reasoning when solving problems, and substantiate conclusions based on spatial information. Spatial thinking should, therefore, form an integral part of the curricula of all spatial modules. Spatial thinking can be taught and developed through the correct teaching and learning processes. These teaching processes include the use of tools of representation, the cognitive level at which the teaching is offered and learning is assessed, and the use of appropriate spatial concepts.

Research on spatial thinking on the African content, in general, and specifically in South Africa, is limited. Up to now most of the research regarding spatial thinking has been conducted in the USA, with focus on assessing teaching methods to improve spatial thinking skills and gauging the spatial thinking skills of students. A comprehensive model for the improvement of spatial thinking in undergraduate spatial modules is lacking, and this shortfall is addressed by this research. The development of the model is based on the PhD research of one of the authors.

This research aimed to develop a model for the improvement of spatial thinking in specifically undergraduate Geography at South African universities, but can be expanded to include the full spectrum of spatial modules. The model was developed based on the achievement of three objectives. The first objective was to determine the current nature of the incorporation of spatial thinking in the syllabi of undergraduate spatial modules at South African universities. In this way modules that may incorporate spatial thinking in their learning methods and support materials could be identified. The second objective was to conduct a critical assessment of the methods used by the lecturers to convey the content of the sampled undergraduate spatial modules to students and their disposition to include spatial thinking in their teaching methods. The third objective was to reflect on the spatiality of the questions posed in the formative and summative assessments of the identified modules and gauging the spatial thinking capabilities of the students enrolled for these modules.

To identify undergraduate spatial modules with curricula that may include spatial thinking, the module outcomes available on the website of Geography departments were assessed against the taxonomy of spatial thinking. If the module outcomes were not available, the module descriptions were scrutinized to determine if spatial thinking may potentially be included in the curricula. Once the modules were identified, the relevant Geography departments were contacted and invited to

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participate in this research. In this way eighteen modules from six universities formed part of this research, comprising a selection of Geography, GIS and Mapwork modules.

Permission was obtained to contact the lectures of these modules. A further in-depth study was conducted by interviewing 21 lecturers to determine if the way in which they convey the module content has the potential to develop the students' spatial thinking skills. This was done by assessing the methods employed by the lecturers against the taxonomy of spatial thinking. The lecturers were also requested to complete a disposition test to determine if they are inclined to include spatial thinking in their teaching methods. During the interviews, the formative and summative assessments from 2019 to 2022 were obtained from the lecturers. The questions included in the formative and summative assessments were evaluated against the taxonomy of spatial thinking to determine if the assessments would contribute towards the development of student's spatial thinking skills. Finally, the students of these modules were requested to complete the spatial thinking ability test (STAT) to gauge their spatial thinking abilities. To develop the model for improving spatial thinking in undergraduate spatial modules, the collected information attained through the achievement of the three objectives were processed and analyzed to feed into the model. Once the initial model had been developed, the selected universities were invited to participate in a feedback session. Based on the comments from the lecturers, the final model was refined.

Since there is no all-encompassing method for teaching in Geography departments, a model for improving spatial thinking should allow for unique adjustments within each specific department and each specific spatial module. The model that has been developed points towards the need for a concerted effort and establishment of an accommodating environment on a departmental level to facilitate the improvement of spatial thinking in modules. The process of imbedding spatial thinking within the model takes the form of a circular process. To begin with, spatial thinking should be considered at the stage when curricula are designed and module outcomes are formulated. Once this been done, lecturers need to consider the composition of the syllabus of each module, and how the modules will be developed. Lecturers need to ensure that the spatiality of the module design and syllabus aligns with the spatiality of the outcomes, Similarly, the spatiality of the teaching methods should align with the module design, syllabus and outcomes. This can be achieved by following a spatial problem-solving process, implying the deliberate use of spatial concepts and employing geospatial tools to convey content. The spatiality of the formative and summative assessments should also align with the spatiality of the teaching methods, design considerations and module syllabus and outcomes to develop students' spatial thinking skills. Should this circular process not be followed or should the spatiality of the different aspects of the module not align, the spatial thinking skills of the students will not be developed adequately. To ensure the successful implementation of spatial thinking as part of the curriculum, the taxonomy of spatial thinking, as developed by Jo and Bednarz (2009), and the STAT, as developed by Lee and Bednarz (2012), takes a central role to the circular process. These are two currently available tools that can be used consciously to ensure that teaching and learning methods are fostering students' spatial thinking skills. Last but not least, the successful implementation of spatial thinking in spatial modules depends on lecturers' positive disposition to include spatial thinking in their teaching methods.

This research calls on universities to implement the model that has been developed for improved spatial thinking as part of their curricula and recommit to teaching spatial thinking to undergraduate students in Geography departments. In doing so, students will be empowered to become spatial citizens and to contribute to informed decision-making on various levels in an ever-changing world.

**References**

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