CHAPTER 5

Supporting Student Teachers to Teach Catchment and River Management in Geography

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Introduction

The inclusion of new environmental knowledge in the South African Geography Curriculum and Assessment Policy Statement (CAPS) has meant that many student teachers are unprepared to teach a systemic process like catchment and river management, which concerns the management of water catchment basins and the rivers within. New environmental knowledge, by definition, involves systems thinking towards a grasp of social-ecological systems, notably cause and effect processes, and circularity within a system. A social-ecological system is the complex relationship between the social and ecological processes on a parcel of land. The need for such systems thinking is implicit in the catchment and river management component of the CAPS (South Africa DBE 2011). The teaching of a case study of a catchment management system (which is the management system that governs a water catchment basin) has never been included in any previous curriculum.

Water management has developed on a widening scale into the 21st century in South Africa, but there was little comprehensive data on catchment management systems until 2017. It was only in July 2017 that a draft catchment management strategy was published. Hence it is not surprising that no curriculum case studies exist since there was no data to base them on (Meissner et al. 2017). An internet search in June 2020 uncovered no trace of any catchment management strategy for the more densely populated and, arguably, more significant eastern catchments of the country.

This study analyses the navigation of social-ecological systems thinking in the curriculum topic of catchment and river management by student teachers at a South African university. The data was generated during field work within teaching practice in the northern Drakensberg foothills of KwaZulu-Natal, South Africa. The first author of this chapter (henceforth referred to in the first person in descriptions of the case study), besides convening a specialised course on catchment and river management for the student teachers before their teaching practice, also acted as a university tutor (assessor) to the students during the fieldtrip-based teaching practice. My role as convener or lecturer ended before the teaching practice experience, however.

The aim of the chapter is to identify and probe the translation of social-ecological systems theory into the CAPS catchment and river management topic through teacher training and student teaching practice. The research design sought to examine the emergence of social-ecological systems thinking and identify challenges to the inclusion of social-ecological systems thinking in the curriculum. It is hoped that this chapter will aid and inform the teaching of catchment and river management, especially in rural contexts where issues associated with this environmental challenge are becoming a critical concern for future sustainability.

Systems thinking, which is an approach that understands systems as its central focus, has emerged as one of the priorities in Education for Sustainable Development (ESD) (Wiek et al. 2011). This is mirrored by a widening of the field from fluvial or water-based processes and physical geography to ‘social-ecological’ perspectives and catchment management. The scope of the research on systems thinking and ESD with student teachers in the Geographical Sciences was as follows:

- What evidence of social-ecological systems thinking is apparent in the student teachers’ field-work-based lessons?
- What issues are associated with the translation of social-ecological systems theory into teaching practice?

By addressing these questions, the study intends to inform continuing work on the integration of social-ecological systems thinking in teacher training programmes, as the need for a wider grasp of changing environment and sustainability concerns becomes increasingly important in schooling.

Curriculum and pedagogical content

The teaching of catchment and river management has had an uneven history in South Africa. It was not mentioned at all in the first post-apartheid curriculum, the National Assembly Training and Education Department (NATED) Interim Syllabus (South Africa DoE 1995). This curriculum, however, did contain emphasis on systems thinking and natural systems. In the next iteration of the National Curriculum, the 2003 National Curriculum Statement, catchment and river management was mentioned as a sub-topic under South Africa and fluvial processes. No other details or specificity was

given (South Africa DoE 2003). It took until 2011 for the curriculum planners to spell out exactly what catchment and river management should cover:

- Catchment and River Management (3hrs) (Under Geomorphology, Grade 12 in Term 1);
- Importance of managing drainage basins and catchment areas;
- Impact of people on drainage basins and catchment areas;
- Case study of one catchment area management strategy in South Africa. (South Africa DBE 2011: 43)

Globally, there are now numerous publications and programmes that have started to provide salient pedagogical guidance on the teaching of catchment and river management, informed by complex social-ecological systems thinking. For example, the United Nations Educational, Scientific and Cultural Organization (2010) offers useful practical guidance on mountain water management systems. An Australian initiative, Streamwatch, contains many helpful pedagogical and other suggestions on how to take care of streams and rivers (Streamwatch 2012). In South Africa, the Mini-Stream Assessment Scoring System (mini-SASS) programme has developed social learning pedagogies that enable adaptive catchment management via citizen science (Vallabh et al. 2016).

Social-ecological systems and practice architecture lenses for the study

The term ‘social-ecological system’ derives from Berkes and Folke (1998). Social-ecological systems thinking and practice is a rapidly emerging area of study in the sustainability sciences, and is influenced by theorists on transdisciplinarity and complexity. Regarding complexity and social-ecological systems, the analysis in the study was influenced by Hahn, Schultz, Folke and Olsson (2008).

The social-ecological system model posited by Hahn et al. (2008) was originally proposed as a model for a wetland outside Stockholm in Sweden that was impacted by major human interaction, but it has since found currency all over the world. The model is based on five core concepts, namely:

- external drivers, change and surprise;
- social norms and rules;
- management: actors and organisations;
- ecosystem functions and dynamics;
- knowledge systems and social memory.

The anchor concept in the model is ecosystem functions and dynamics, which are influenced by external drivers of change and surprise. Simultaneously, the anchor concept is influenced and affected by human interactions, namely: social norms and rules; management actors and organisations; and community knowledge systems and

social memory. The model was chosen because the study site in the northern Drakensberg was relevant to all five core concepts. It also aligns with new environmental knowledge in the curriculum. This model, which is informed by (and informs) social-ecological systems theory, was helpful in answering the first research question:

What evidence of social-ecological systems thinking is apparent in the student teachers' field-work-based lessons?

Practice architecture is a theory whereby the system or architecture of practice, or the way things are done, is systematically analysed. Mahon, Francisco and Kemmis describe practice architectures as 'a contemporary account of social reality that focuses on practice' (2017: 2). Schatzki posits that practice architecture is a system within which 'practices are organised nexuses of actions' (Schatzki 2002, in Kemmis 2009: 27). Kemmis et al. (2014) illustrate practice architecture in a model where sayings, doings and relating (practices) are shown to emerge, respectively, from arrangements of cultural-discursive, material-economic and socio-political architectures. By understanding these three arrangements, one can analyse how the landscape of architectures is influencing the practices. Practice architecture was thus viewed as an appropriate lens to shed light on some of the factors influencing the translation of social-ecological theory into the teaching practice context for this study. This helped to answer the second research question:

What issues are associated with the translation of social-ecological systems theory into teaching practice?

Methodology

The study was designed as a case study of a teacher education process, and was undertaken in the upper uThukela catchment basin between Bergville and the Royal Natal National Park in central KwaZulu-Natal. Consent was obtained from the five student teachers as well as the three schools in order to meet ethics requirements for research with human participants.

My role was that of a university tutor, supervising students on teaching practice. This was complicated by my other role as facilitator of the teaching practice experience. Moreover, in a previous phase of research, I lectured the same students in a specialised course on catchment and river management, in addition to lecturing them during the regular Postgraduate Certificate in Education course. The specialist course was intended to prepare the students to teach the topic of catchment and river management in the curriculum. My interest was to see how social-ecological systems theory translated into a context that is representative of many other South African communities. In my case the context was informed by the education I had received in environmental and geographical science and regional planning, as well as by my recreational pursuits in mountainous areas and my own ecology-based values.

Data were generated from student teacher lesson plans and reflective reports, which comprised the teaching practice record. Additionally, formative assessments written by me (the university tutor) were used to shed light on the systemic (in terms of social-ecological systems) elements in the lesson plans that the students developed for teaching the topic.

Two lenses were employed to answer the above-mentioned research questions, namely the social-ecological systems lens (the Hahn et al. model) and the practice architecture lens, to review the teaching of social-ecological systems thinking in relation to catchment and river management in a rural schooling context. In terms of the social-ecological system, following the Hahn et al. (2008) model, the following components were used to analyse the data from the student teaching practice records: external drivers; change and surprise; social norms and rules; management in the form of actors and organisations; ecosystem functions and dynamics; and knowledge systems and social memory. For practice architectures, the data was analysed in terms of the following arrangements: cultural-discursive; material-economic; and social-political.

Findings

The sections below report on the findings in relation to the two research questions.

Evidence of social-ecological systems thinking

This section presents data in relation to the first research question (What evidence of social-ecological systems thinking is apparent in the student teachers' field-work-based lessons?). It reports on the five aspects of systems thinking identified by Hahn et al. (2008). Regarding the first component of the model, external drivers, change and surprise, the significance of this became apparent during the student teachers' field work with the learners. The weather was a major external driver, affecting the level of the uThukela significantly following a cold front (mid-latitude cyclone) that passed through the area in the first week of teaching practice. A thunderstorm with lightning affected one field work lesson, forcing the student teacher, university tutor and learners to move quickly to a classroom.

The second component of social-ecological systems thinking, social norms, was noted by students in their reflective reports. One student reported on how environmental issues and risks emerging from local practice had been incorporated into the lesson. She explained that: 'There was evidence of pollution, erosion, mining and mis-utilisation of the riparian zone ... This questionnaire was to give learners a clear picture of how the community has damaged the environments of the river banks and have impacted on the water quality and state of the natural environment.'

Management by actors and organisations (the third social-ecological dimension), or the lack thereof, was given prominence in the student teachers' lessons during the fieldtrips. In particular, the teaching of a catchment management strategy case study (a requirement in the CAPS) proved difficult for some students in terms of clearly

illustrating scale and zoning in a catchment. One student noted: 'I should have provided with a strategy that would manage the whole catchment not the small areas of a catchment ... therefore I had to repeat the lesson ... The lesson was supposed to be orientated around one strategy in a catchment ... The objectives did not orientate around a specific catchment management strategy.' In these two quotes, the student teacher is referring to a single catchment management strategy, which uses zoning to separate land use, for a particular catchment.

On occasion, activities were orientated around the impacts of people on catchment basins, whereas they needed to be orientated around a catchment management system. In particular, activities needed to be re-aligned to a bigger scale for a catchment management system because the whole catchment, not just a small part of it, is the focus. This was seen in the following comment from a lesson assessment form: 'Re-align to a macroscale for a catchment management system.' Human impacts would also fall under management in the sense that management decisions, or the lack of them, contribute to the negative effects that people can have on a catchment, as evidenced in this feedback comment to one of the teachers: 'A good section but please understand the nuances of human impacts: dams, IBT (interbasin transfer) (mostly negative).'

It appeared that key understandings and concepts regarding the management of social-ecological systems and catchments, which the student teachers conveyed to learners, were sometimes confused and related in disassociated ways during the field-work-based teaching practice: for example, the sketch maps that the student teachers drew provided evidence of scale confusion, and no understanding of the boundaries of a catchment basin. Geographic discontinuity was evident when one student confused the zoning of the catchment during a class mapwork activity.

From an ecosystem perspective (the fourth dimension of social-ecological thinking), students focused on the river basin. The mini-stream assessment scoring system (SASS) experiment was used in an appropriate and successful manner most of the time. However, there were two areas where a need for improved understanding became apparent. First, a student confused atmospheric concepts (in that the student thought a catchment gave all the oxygen people need). Second, there was some inappropriate use in terms of systems thinking (in the misconceptualising of scientific processes, such as a student confusing an area that had been made wet by a leaking tap for a wetland). I emphasised that on a fieldtrip it is also very important for learners to measure what is seen (human impacts on catchment areas needed to be measured using experiments, observation and measurements). An ecosystem perspective was evidenced by the statement in a reflective report that: 'My learners were very happy about this activity (the mini-SASS) and enjoyed it as they were looking for the different animals in the river. They were very disappointed by the result as they showed that the Thukela River was not healthy.'

Regarding the dimension of knowledge systems, one student explained that 'the lesson was to focus on using indigenous knowledge and also extracting the knowledge that the learners carry with them in terms of protecting and preserving the rivers.' Significantly, one student teacher noted that 'the spring was not even recognised by members of the community hence I [taught] my learners ways of conserving and

managing springs.’ This implies that, while one can have the intention to mobilise indigenous knowledge, in some cases a community may not be forthcoming in sharing information about what might be a precious resource which has cultural or core survival significance in the area.

Practice architecture relationships in teaching practice

This section seeks to answer the second research question (What issues are associated with the translation of social-ecological systems theory into teaching practice?).

Material-economic architectures

The three secondary schools in which the students were teaching serve a very poor community with high unemployment. None of the schools had a library and the nearest one for learners was the municipal library in Bergville, 50km away. The schools were sparsely furnished, with only chairs and desks, a blackboard and a teacher’s desk furnishing the classroom. There was no educational material on the walls. The fieldtrip lessons were characterised by low learner turnout at times. Rural poverty undoubtedly affected the turnout, and this in turn affected the successful delivery of the content. For this reason, I suggested to one student teacher that she use the strategy of repeating her lesson, in a classroom format, to the whole class. The student teachers were limited by only being able to teach on Saturdays, as the timetable during the week did not allow for the length of time needed for a fieldtrip.

The fieldtrips were held in two severely degraded quinary catchments, with very visible evidence of overgrazing and poor land management in the form of denuded slopes and erosion gullies (dongas). A quinary catchment is the smallest scaled catchment there is, being the fifth level catchment after primary, secondary, tertiary and quaternary catchments. This poor land management (sand mining occurred while I was there supervising the students) has had many other effects such as sheet erosion. This affected the enjoyment (and the motivation) of the fieldtrip for all concerned, including the student teacher, me as the assessor, and the learners, as no one enjoys degraded surroundings.

The one quinary catchment in which two of the three high schools were situated, was ideally placed for student teachers and learners to analyse and understand the social-ecological system framework. The very important uThukela river also runs through it from the sheer escarpment above to the inhabited areas underneath. Land use differentiation occurs as the protected area (Royal Natal National Park) is reasonably pristine. However, just across the river; sand-mining, extensive road building, and pollution occur.

The other quinary catchment, in which the second high school was situated, is very different in character as it is far from a protected area. This catchment also does not have a major river running through it but only tributaries of the uThukela. The Khombe river lacks the stature, in terms of width and current, of the uThukela. However, the

student at School C did not take his learners to this river but to an even narrower stream closer to the school. This affected the lesson in that learners did not appreciate the dimensions and effects of a significant river.

Cultural-discursive architectures

The social-ecological systems discourse that the students had been exposed to before the teaching practice would have influenced their general understanding of what to include in lessons. I assumed, as a point of departure, that the students would have been fully conversant with the theories of social-ecological systems, as well as catchment and river management. This was after they had attended a dedicated course on those two topics. Indigenous knowledge systems were not referred to explicitly. Rather it was couched in terms such as ‘what we have learnt from our families and communities’; nonetheless, it did play a role.

The Curriculum and Assessment Policy Statement provided a major underpinning architecture to teaching practice experience, as it was the CAPS that informed the lessons to be taught. In particular, fieldtrip lessons had to cohere around a particular sub-topic under catchment and river management. This was evidenced by one of the comments on a lesson assessment form: ‘Don’t confuse or mix the subtopics – the [fieldtrip] lesson must cohere around one subtopic (Impact of people on catchment areas, and importance of catchment areas mixed).’ Moreover, in the case of the catchment management strategy case study prescribed by the CAPS curriculum, the curriculum can be said to be ahead of reality as only one catchment management strategy has been drafted in South Africa, and that is not in the eastern half of the country. National and provincial education policy influenced the norms and standards expected in lessons, as in the performance criteria stated in the lesson assessment form.

Social-political architectures

The altered power relationship between me and the students affected how I related with them in that my role prior to assessing the lessons had been a facilitative and enabling one. I had to adapt to being a critical assessor and the students also had to adapt to considering me in a new role and light. A particular concern of mine was to ensure lesson coherence around the particular sub-topics in catchment and river management, and to ensure that the correct geographical terms and concepts were used. In addition, I was a complete outsider to the community of the area, in that I did not understand the vernacular language, nor was I aware of some of the cultural and social precepts that may have been present while I was there. However, I felt welcome and enjoyed my experience there.

Regarding the presence of political authorities and management, there was no evidence of any land or other kind of management at all, which is a political function. No government offices, including police stations, were visible during the fieldtrips. The area should actually comprise a buffer zone adjacent to a formally protected area,

according to environmental law as mentioned below, but this is not the case. No activities damaging to the formally protected zone are normally permitted in a buffer, with only farming allowed in the next zone that occurs, the transition zone. This is supported by the uKhahlamba Drakensberg Park World Heritage Site (UDPWHS) Integrated Management Plan (Ezemvelo KZN Wildlife 2012). From what I and the student teachers observed, these principles are not being followed, nor are illicit activities being discouraged within the stipulated five/ten-kilometre border zone from the Royal Natal National Park (an integral part of the UDPWHS) boundaries. However, it should be borne in mind that the area has a long and contested history, with an initial resettlement of surrounding communities to this area during the colonial era (the Upper uThukela Location) (Pearce 2006). The area also experienced at least one major incident of political violence and a failed apartheid-era plan to move people from the area (Wright & Mazel 2007).

Discussion of the pedagogy of catchment and river management

To answer the first research question (What evidence of social-ecological systems thinking is apparent in the student teachers' field-work-based lessons?), the student teachers' capital, in terms of social-ecological systems thinking, was not easily translated into rural classroom settings. For the ecosystem element, the mini-stream assessment scoring system experiment was used by student teachers in lesson topics such as the impact of people on a catchment basin, and the importance of catchment basins. As mentioned above, there were some misconceptions around ecosystems such as misunderstanding oxygen production and wetland formation. There was also a need for spatial skills and concepts necessary for a more coherent or holistic grasp of fluvial systems and river catchments as interacting social and ecological systems and processes.

The data informing this chapter suggested that there was an issue with student teacher knowledge both in terms of grasp of the content and the pedagogic challenge of working with systemic concepts (Hahn et al. 2008; Norberg & Cumming 2008) in a rural teaching and learning context. Poorly developed geospatial reasoning directly affected landscape and scale literacy (which requires being able to interpret and apply an understanding of geographic scale, as in map scale) on the part of the students. Regarding management actors and organisations, students misunderstood what a catchment management strategy involved, and did not reference the management entities enough in their lessons.

What was significant were the insights that students drew from their own experiences and social backgrounds. These insights included indigenous knowledge systems; references to the purifying nature of rivers; and the fact that the rivers were a community possession to be protected. Their major strength was the social side of social-ecological systems thinking, that enabled them to mediate their learning from the strengths of their social awareness (the social norms element shows that students were concerned by how little the community understood of the importance of the catchment, and how they treated it).

Some also used heritage knowledge/indigenous knowledge systems (as mentioned above in regard to the purifying qualities of rivers) to illustrate ecological concepts (Hahn et al. 2008). In this regard, there did appear to be a willingness on the part of students to mobilise indigenous knowledge systems, but this was hampered by the community not being aware of, or not volunteering knowledge of, life support systems such as springs.

Partial understandings and associated misconceptualisations were factors in obstructing a systems-approach to the study area as well as the social-ecological elements of the curriculum being taught. Widespread and deep-seated issues did impact the teaching and learning process. These affected both the social-ecological systems focus of the field work context (teaching catchment and river management in a deep rural environment) and the academic performance of the student teachers in their teaching practice.

The findings above showed that, regarding social-ecological systems thinking, the teaching and learning process was non-linear and complex. For example, the most prominent external driver was the weather, which informed the level of the rivers after a cold front and also disrupted a field work lesson due to a thunderstorm. In a number of cases, lessons had to be repeated and the student teacher was counselled on the topic and systems coherence of a lesson.

To answer the second research question (What issues are associated with the translation of social-ecological systems theory into teaching practice?), a number of contextual factors, as elaborated in the summary below, worked together in unison to ensure that the process was highly complex, circular, historical and social (the last two factors comprised feedbacks) (Norberg & Cumming 2008). Circularity refers to the ongoing and repetitive complex processes within a system, while feedbacks refer to continuing influences from both history and society. The key trends point to a multi-contextual teaching and learning environment affecting the teaching practice. The summary of the material-economic architectures shows the following factors at play: (a) the three schools' environments were very poor and environmentally degraded with the schools themselves being sparsely furnished, (b) the fieldtrip lessons had very low learner turnout and had to occur on Saturdays, (c) the quinary catchment closer to the protected area was more ideal for fieldtrip lessons than the other site, on the other side of the common watershed.

Regarding the cultural-discursive architecture factors, social-ecological systems discourse predominated with indigenous knowledge systems being referred to obliquely. The Curriculum and Assessment Policy Statement underpinned the structure and content of the fieldtrips with other national and provincial policy providing the norms and standards.

In terms of the factors of social-political architecture, there was a different power relationship between myself and the students to that which had been experienced previously. In addition, I was an outsider to the community belonging to the study area. I was especially focused on ensuring lesson coherence and correct geographical terminology on the part of the student teachers. There was no evidence of any land

or any other political management at all in the area. The buffer adjoining the formal protected area was not respected at all in terms of environmental law, and the area as a whole has a contested history with at least one serious case of political violence.

Conclusion

This study explored how social-ecological systems thinking was taught by student teachers while on a field-work trip, after having attended a specialised course on catchment and river management. The students were responsible for teaching the three sub-topics of the catchment and river management section of the current South African Senior School curriculum. The work on this challenging section of the curriculum was undertaken as a process of learning and re-learning (for those students who needed to repeat their first teaching practice lesson) with student teachers who were teaching in a rural schooling context. The study has the potential to inform interventions in poor and rural schools where there are significant issues with the preparation of teachers to teach the new environmental knowledge in the curriculum.

Recommendations from this case study are that varied and broad responses to the noted multi-contextual challenges are needed in order to prepare and equip student teachers for the demands of the new environmental knowledge in the curriculum. In this case, Bachelor of Science graduates with majors in Environmental Science and Geography did not yet fully understand and conceptualise the social-ecological systems approach inherent in the curriculum. The practice architectures' (cultural-discursive, material-economic and social-political) analytical lens used to review the pedagogical context of teaching practice suggested that there were multiple contexts and influences in the rural setting where the schools were situated. There were also different institutions affecting practice such as a university and the Provincial Department of Education. Certainly, difficulties with geographic concepts such as scale, boundaries and atmospheric processes had a significant influence on teaching and learning. Therefore, when setting curricula, education department curriculum specialists need to cater for widely differing social contexts of teaching and learning to take account of what is actually occurring in the field. In particular, field work needs resources and specialised teaching aids that all three schools in the study did not have.

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