been fully aware of the benefits of aiming for deep geographic learning. Second, these teachers may not have been confident enough about their ability to organize one-on-one or whole-class discussions on this topic, as it required them to have a good domain-specific construct for use in educational settings in their mind (see Challenge 2), and have enough knowledge to diagnose problems and support students in their geographic thinking (see Challenge 4).

Challenge 6: Challenges due to insufficient declarative, procedural, and/or strategic knowledge in the component ‘GIS-TPCK&M’, sub-component ‘technology-supported domain-specific inquiry knowledge for use in educational settings’. The teachers were sometimes unable to support students who wanted to do something extra because they had only knowledge about the standard procedure of project Services and Customers, and limited knowledge about other suitable inquiry procedures for a GIS-supported geographic inquiry project on the same topic (see, for example, Sections 11.2.4.2 and 11.5.3.1). This challenge had a deeper cause: the teachers had little knowledge about how to use GIS in geographic inquiry themselves (see Table 11-1).

Challenge 7: Challenges due to insufficient declarative, procedural, and/or strategic knowledge in the component ‘GIS-TPCK&M’, sub-component ‘technology-supported domain-specific inquiry tasks, coaching, and student learning processes’. GIS requires students to make their problem solving strategies explicit, which can be quite difficult for them. It is therefore important that students are properly supported. However, the teachers who participated in the design process were sometimes unable to diagnose problems caused by learning difficulties when students were working with Excel and GIS. Also, they were sometimes unable to take over tasks, and/or unable to support students in such a way that they can overcome these problems (see, for example, Sections 11.2.4.4, 11.4.4.2, and 11.5.4.3). This threatened the viability of the project. It turned out that there were two deeper causes for this challenge. First, the teachers had sometimes often forgotten a part of the standard GIS procedure of the project (see Challenge 6). Second, the teachers sometimes did not have enough knowledge about how to overcome technical problems when they work with GIS themselves, which can be seen as a lack of knowledge in the GIS-TCK component.

Figure 13-2B shows the seven challenges described above in the teacher-competency framework. The figure shows the interdependence between the different challenges. A survey among the teachers who participated in the design process of the project ‘Services and Customers’ (see Table 12-3) showed that the main challenges experienced by teachers were related to insufficient declarative, procedural, and strategic knowledge in the TK, TPK, TCK, and TPCK components. They found that they had enough declarative, procedural, and strategic knowledge in the PK, CK, and PCK components to provide optimal coaching (Figure 13-2). So the teachers’ opinion matches only partially with the conclusions drawn by the researcher on the basis of the data collected during the design process. A similar discrepancy between teachers’ opinion about their own competencies and what they actually do in the classroom has been noticed by Wildschut & Van der Schee (2007).
Most of the challenges mentioned above did not only apply to the teachers, but also to the researcher. In the first couple of cycles, the researcher did not focus on stimulating deep learning either (see, for example, Section 11.1.2.1 and 11.2.2.1). Furthermore, he did not have a good domain-specific construct for use in educational settings in his mind, and did not know how to develop such a construct (see Section 11.3.2.1). For this reason, he was not able to diagnose inquiry planning-related and geographic thinking-related problems in the first couple of tests, and was not able to organize an effective whole-class evaluative discussion (see Section 11.1.4.3 and 11.2.4.6).

In the course of the design process, the number of situations in which the teacher was unable to diagnose the remaining problems caused by learning difficulties decreased considerably. The number of situations in which the teacher was unable to support students in such a way that they are able to overcome the problems also decreased. Besides this, it was also noticed that some teachers took on a far more active role, and engaged in much more discussion with students when they conducted the project for the second time than in the first time. This shows
that the teachers had gained more knowledge and motivation in the different components of the teacher-competency framework, and that the challenges gradually decreased. However, some teachers showed much more progression than others.

The question is: Can we blame the teachers for providing less-than-optimal coaching? No, the teachers cannot be reproached. Teaching with GIS is very complex. Also, it was very new for the teachers who participated in the design process of the project ‘Services & Customers’. Most of them were fresh or almost fresh to teaching with technology, were not very experienced in conducting geographic inquiry projects that combine fieldwork with geodata analysis in maps, were not used to aim for deep geographic learning, and had never heard about the formal geographic language. This is no surprise, as they had never been educated in these fields! Still, we have seen that teachers who are representative for the teacher population are able to learn how to conduct a rather difficult GIS-supported geographic inquiry project in two rounds.

A step-by-step approach is recommended for teachers who want to start teaching geography with GIS. However, in the practical part of the PhD study, we took one large step instead of a couple of small steps. Still, most of the teachers made considerable progress. Even though it was complex and new for them, most of them were able to provide viable and effective coaching when they conducted the inquiry project for the second time. So it can be said the teachers did a great job.

The next question is: What can we do to help other teachers who have no experience in conducting GIS-supported geographic inquiry projects yet? Offering courses about how to teach geography with GIS is one of the keys to help them. It is recommended to design courses around the ready-to-use GIS-supported geographic inquiry projects. Courses should pay attention to the learning goals of the project and the learning goals of secondary geography education in general (i.e. deep geographic learning), the development of teachers’ knowledge and motivation in the different components of the teacher-competency framework, and the practical and organizational issues of teaching with GIS. Now follow some ideas about the set-up and content of a course for in-service teachers around the project ‘Services and Customers’. Such a course should consist of the following phases:

**Phase I: Introduction.** The course should first try to arouse teachers’ curiosity about teaching with GIS, and arouse teachers’ motivation to learn about how to teach geography with GIS, for example by letting them construct maps on the basis of an Excel file with geodata collected by students. The next step would be to discuss the learning goals of the course: to develop the knowledge needed to conduct the project in an optimal way.

**Phase II: Knowledge development in the component ‘Geo-PCK&M’, sub-component ‘domain-specific knowledge for use in educational settings’.** This phase aims to teach teachers how to reorganize their disciplinary subject knowledge and disciplinary inquiry methods knowledge on the topic of services and customers, and to transform it so that it becomes accessible for students in the form of a good domain-specific construct for use in educational settings, and in such a way meet Challenges 2 and 3. It might be a good idea to construct a theory about the size of market areas of services in the form of a list of rules and generalizations, and in the form of a symbolic representation, by organizing a whole-class modelling task (for an example of an effective modelling task, see Section 11.5.4.2). Maps constructed by students (see, for example, Figure 10-3) and texts from the literature (see, for example, Table 10-3) may form the input for such tasks. Together, the teachers and teacher trainer can try to deduce the relationships that
are present in these maps and texts, and discuss which of these relationships are spatial relationships. The domain-specific construct for use in educational settings should also consist of a list of potentially effective survey questions. In order to construct such a list, it might be a good idea to let teachers select potentially effective survey questions from student inquiry plans (see, for example, Table 10-7), and ask them to formulate better alternatives, taking into account that there should be a strong link between the survey questions and the theory about the size of market areas of services.

Phase III: Knowledge development in the component ‘Geo-PCK&M’, sub-component ‘domain-specific learning goals’. In this phase, the teacher trainer should discuss the benefits and implications of focusing on deep geographic learning with the teachers, as high learning outputs can only be reached by setting high and concrete learning goals. Teachers should be made aware that deep geographic learning is a goal that is worth pursuing. So this phase aims to meet Challenge 1. It might be a good idea to let teachers formulate the learning goals for the project ‘Services and Customers’, thereby using the domain-specific construct for use in educational settings developed in phase II.

Phase IV: Knowledge development in the component ‘Geo-PCK&M’, sub-component ‘domain-specific inquiry tasks, coaching, and student learning processes’. This phase aims to teach students how to design effective geographic inquiry projects, and meet Challenge 4 and 5. At the start of the phase, the teacher trainer could present the model for the set-up of GIS-supported geographic inquiry projects (see Figure 13-1), and then discuss with the teachers how to set up the project in order to stimulate deep geographic learning. The teacher trainer should stress the benefits of including preparatory and evaluative whole-class discussions in which teachers discuss the geographic content with their students. It might be a good idea to show a videotape of a successful preparatory or evaluative whole-class discussion (see, for example, Section 11.5.4.2). After this exercise, the teacher trainer could tell the teachers about frequently occurring β problems as a result of student learning difficulties, and discuss how to prepare students in order to avoid such problems, or how to support students so that they are able to overcome these problems. There should be a strong link with the domain-specific construct for use in educational settings developed in phase II. It might be a good idea to let the teachers analyse videotapes of student presentations, one-on-one discussions, or whole-class discussions. Such a task could consist of diagnosing β problems with the help of the list of common β problems (Appendix B), and/or classifying teacher interventions with the help of the framework for analysing the support provided by the teacher (see Table 8-2). Together, the teachers and teacher trainer could explore alternative interventions.

Phase V: Knowledge development in the component ‘GIS-TCK&M’ and in the component ‘GIS-TPCK&M’, sub-component ‘domain-specific technology-supported inquiry knowledge for use in educational settings’. This phase aims to teach teachers about the structure of GIS, and about how to use GIS in simple geographic inquiry projects. Teachers should not only learn to conduct the standard procedure of the project ‘Services and Customers’, but also to conduct other procedures that could be applied in inquiry on the topic of services and customers. Assignments should start with a question, and show how GIS can be used to answer the question.

Phase VI: Knowledge development in the component ‘GIS-TPCK&M’, sub-component ‘technology-supported domain-specific inquiry tasks, coaching, and student learning processes’. This phase aims to teach teachers about frequently occurring α problems caused by student
learning difficulties, and learn how these problems can be avoided or overcome. So this phase aims to meet Challenge 7. It might be useful to let teachers experience the α problems themselves, for example, by letting them work with geodata tables that do not meet the criteria of a proper database table.

**Phase VII: Discussion about the practical and organizational issues.** The final phase of the course should focus on the question how to arrange software and educational materials, and how to plan the project.

As teaching with GIS is a large and complex educational innovation issue, it is clear that learning to teach geography with GIS is not a question of following a one-day course. Teachers should follow several courses and engage in extensive self-study. The best way to learn how to teach geography with GIS is by experience: teachers should just start conducting simple GIS-supported geographic inquiry projects. In-class support from experts could be very useful. In the USA, ESRI’s geo-mentoring programme aims to bridge the gap (www.edscommunity.esri.com/geomentor/index.cfm). In the geo-mentoring programme, GeoICT experts help teachers in designing and conducting GIS-supported geographic inquiry projects with their classes. Although the help of Geo-ICT experts is very much appreciated by teachers, it mainly focuses on the organizational, practical, and technical issues. We have seen in this dissertation that teachers could also use some help on the didactical issues. Teachers who are experienced in teaching with GIS should help their colleagues. Such expert teachers could help them diagnose α problems caused by student learning difficulties when the students are working with GIS, and subsequently show them how to overcome these α problems. Some of the teachers who participated in the design process of the project ‘Services and Customers’ now have such an expert role within their school. They made their colleagues enthusiastic about teaching with GIS, and now support them in conducting GIS-supported geographic inquiry projects. This is a promising approach: teachers working together in small groups, exploring how they can use GIS to improve their teaching and help students learn more.

In conclusion, we have seen that GIS holds many opportunities for enhancing secondary geography education, but also that there are many conditions for the optimal use of GIS. Teaching with GIS is difficult. Teachers are therefore recommended to follow a step-by-step approach and start with simple GIS-supported geographic inquiry projects.

### 13.2 Discussion

#### 13.2.1 Reflection on the research approach

Now that we have learned about the outcomes on the design process, it is time to raise some points of reflection on the research approach of the practical part of the PhD.

First, in order to produce the desired output, the teachers who participated in the design process had to take large steps. The design process did not aim to develop a GIS-supported geographic inquiry project that was viable for the entire teacher population in the Netherlands. Instead, it aimed to find out, among others, what makes a GIS-supported geographic inquiry project viable for teachers. So instead of playing safe and making the design as simple as possible, the research team constantly explored the boundaries of viability. As a consequence, the GIS-supported geographic inquiry project that was developed in the design process is probably too difficult for teachers who are not experienced in teaching with GIS. It is therefore
recommended that these teachers start with simpler GIS-supported geographic inquiry projects. The design principles generated in the practical part of the design process can help to design such projects.

Second, in order to produce the desired output, it was necessary for the researcher to play an active role in the tests. In the test stages of the first three cycles, the researcher frequently took over coaching tasks that the teacher was not able to perform in order to ensure that the learning processes did not get stuck. However, the number of essential take-overs decreased to almost zero in the test stage of the fifth and final cycle. Besides the essential take-overs, the researcher sometimes also took over tasks in order to show the teachers how to conduct these tasks, so that they could perform these tasks themselves next time. Another reason for these non-essential take-overs was that the researcher wanted to have more input for the retrospective activities. The tasks were videotaped and the videotapes were discussed with the teachers. Together, the teachers and researcher explored how the design of the task could be revised to make it more viable and effective. Without these non-essential take-overs, the output of the PhD study would probably have been much lower.

Third, as most of the teachers had little experience with GIS, and as the research team had to use GIS software which was not suitable for use in educational settings, a large part of teachers’ time and energy was spent on technical issues, which left little time and energy for the didactical issues. This was especially the case in the first two or three cycles of the design process. In the near future, when teachers have more technical know-how, and, when good educational GIS software is available, it will be a lot easier to conduct research on how GIS-supported inquiry-based geography education can be realized in practice.

Fourth, in the course of the design process, the learning goals of the project gradually became more specified, the domain-specific construct for use in educational settings improved, much more guidance was offered by the handouts and teachers, and the teachers engaged more and more in discussions with their students. This seemed to work. Each of the design principles presented in this dissertation is supported by preliminary evidence. The research design was not suitable for providing definite proof of the validity of the design principles, and they therefore have yet to be tested in an experimental setting. However, the output of design research should be judged on their ability to do work in practice (Cobb et al.; 2003, p.10). According to Bakker (2004, p.38), EDR should be “evaluated against the metrics of innovation and usefulness, and its strength comes from its explanatory power and grounding in experience”. What really counts is whether the output is useful and reliable enough for teachers to design and conduct lessons with GIS, for teacher educators to organize courses about teaching geography with GIS, and for educational scientists to write handbooks about teaching geography with GIS.

Fifth, during the design process, an attempt was made to improve the quality of the outcomes via triangulation in data source and data interpretation: different types of data were collected; and different members of the research team interpreted the data. The inferences made by the research team are substantiated in the dissertation by including some of the data. However, in order to save space, often only one or two types of data are included to substantiate each conclusion.

Sixth, this dissertation may have a negative air. This is an unfortunate and unjust consequence of the research design. Due to the focus on problems and challenges for teachers to provide optimal instruction, it may seem as if the students and teachers did not perform well. This was
absolutely not the case. Students and teachers certainly did their best, and many good things happened. Students often produced wonderful reports, and teachers often provided excellent coaching.

Seventh, at first sight, some of the design principles generated during the design process may seem very much based on common sense. See, for example, the design principle that teachers should engage in discussions with students on the geographic content and geographic inquiry strategy. It has been known for a long time that such discussions are essential elements of effective inquiry-based education. However, during the test stages, it was discovered that some teachers hardly engaged in discussions with students. So it is certainly not common sense to assume that teachers will actually follow this design principle. Also, it may seem as if some design principles are not very interesting for educational scientists. See, for example, the design principle that says that students should conduct the Excel and GIS tasks at school, under the supervision of a teacher. This design principle has a low value for educational theory development. However, during workshops about teaching with GIS for geography teachers, it was discovered that teachers often wanted to know whether they could let students conduct entire GIS-supported geographic inquiry projects by themselves as homework. In the test stages of the design process of the project ‘Services and Customers’, it was discovered that this is certainly not possible. So, this design principle does answer one of the most frequently asked questions of teachers. In summary, it can be concluded that, although some design principles may seem to be common sense and uninteresting, they are certainly valuable for teachers who want to design and conduct GIS-supported geographic inquiry projects.

Eight and finally, while the aims and research questions outlined in the Introduction to this dissertation provided a guideline for the dissertation, the practical part of the PhD study also had other aims which were more difficult to translate into concrete research questions. First, this dissertation also aimed to explore how the model for GIS-supported geographic inquiry could be used to guide the design of GIS-supported geographic inquiry projects in practice, and to explore how the model and the two frameworks could be used as a research tool to analyse the data collected in the classroom. The model turned out to be a very valuable tool in the design process. It provided a guideline for the design of the domain-specific construct for educational settings, and it provided input for the exploration of possible tasks and teacher interventions to raise students’ geographic thinking to a higher level. In addition, it was a useful tool to get more insight into the nature of students’ learning processes. Furthermore, insights from practice also helped to improve the model. Exploring the characteristics of a good domain-specific construct for educational settings for the project ‘Services & Customers’ helped to improve the section about the nature of knowledge about the world around us (see Section 5.4). Second, the practical part of the PhD study also aimed to explore how the teacher-competency framework for GIS-supported inquiry-based teaching, could be used in educational research. In this research, an approach was used in which the teacher-competency framework was connected to the criteria ‘appropriateness’, ‘legitimacy’, ‘viability’, and ‘effectiveness’. The criterion ‘legitimacy’ was connected to the sub-component ‘constructs for educational settings’, while the criteria ‘viability’ and ‘effectiveness’ were connected to the sub-component ‘inquiry tasks, coaching, and student learning processes’. This turned out to be a very fruitful approach. It helped to analyse and structure the challenges for teachers to provide optimal coaching, to formulate recommendations on how these challenges can be overcome. Experience from practice also resulted in revisions of the framework. For example, it was discovered that it is necessary to include a motivation dimension in the framework, and that it
is useful to include a sub-component about learning goals. Third, the practical part of the PhD study also aimed to provide insight into how GIS-supported inquiry-based education works. The transcripts and interpretations provide insight into the interaction between students’ learning processes and teacher interventions. Fourth and finally, the practical part of the PhD study also aimed to provide insight into the complexity of the educational innovation problem of teaching geography with GIS. It is clear now that it is a very complex problem.

13.2.2 Implications of the outcomes

In the practical part of the dissertation, we have seen that GIS provides many opportunities for enhancing secondary geography education, as it allows teachers to design and conduct inquiry-based geography projects which have the potential to contribute to deep geographic learning in a manner that is different from traditional geographic inquiry projects. However, we have also seen that GIS-supported inquiry-based geography education is a very complex, and that it holds many conditions for it to be optimal. We should therefore raise the following point of discussion: Is it possible to realize optimal GIS-supported inquiry-based geography education, and in such a way raise secondary geography education to a higher level? Yes, we think it is, but that it requires two important actions.

The first action is to provide the infrastructure for teachers in terms of software, geodata and instruction materials. In The Netherlands, large steps have been made in the past five years. The most important stimulus to the diffusion of GIS was the development of an Internet portal for secondary education with GIS, called EduGIS (www.edugis.nl). The Internet portal offers a free WebGIS with hundreds of map layers, and several lessons on topics such as spatial planning, water management, and pollution. This WebGIS and the accompanying lessons have been adopted enthusiastically by teachers in the Netherlands (Favier, Van der Schee, & Scholten, 2011). However, this WebGIS offers only opportunities to view the digital maps. More tools are required in order to conduct inquiry projects in which students use data collected by themselves in the field, and then visualize and analyse this data in GIS. We have seen in this dissertation that professional GIS software is not adapted to the needs of students and teachers, and is therefore not suitable for use in secondary geography education. For this reason, ESRI, which is one of the partners in the EduGIS project, developed an educational GIS software package called ‘EduGIS Lokaal’ in 2010-2011. The design principles for educational GIS software that were generated in the practical part of this dissertation guided the design of the software package. As well as the improvement of the GIS software and geodata infrastructure, work should also be done on the instruction materials infrastructure. We have seen in this dissertation that the development of good instruction materials for GIS-supported geographic inquiry projects is complex and very time-consuming. It requires many cycles of designing, testing, and evaluating. Therefore, we cannot expect teachers to develop such materials by themselves, and other actors in the field of secondary geography education should do it for them. The GIS-supported geographic inquiry projects developed in the practical part of this PhD study form the first step in providing teachers with good instruction materials.

The second action is to train the current and future teacher population. In the practical part of this dissertation, we have seen that the most important requirement for improving the effectiveness of GIS-supported inquiry-based geography projects, it that teachers need to be able to structure their own geographic subject knowledge and geographic inquiry knowledge,
and to transform their knowledge so that it becomes accessible for students. Only then will they be able to design effective tasks and provide effective coaching. The most important requirement for raising the viability of GIS-supported inquiry-based geography projects, is that teachers must work very systematically and provide a considerable amount of structure. The requirement for the effectiveness applies to projects with GIS as well as to projects without GIS. However, the requirement for the viability is far more important for projects with GIS than for projects without GIS. As the success of every phase depends on the success of the previous phase, GIS-supported geographic inquiry projects are more prone to getting stuck. The requirements are therefore to be strictly followed in order to secure the viability of the projects.

The need for professional development of teachers is clear in order to realize optimal (GIS-supported) inquiry-based geography education. In the past few years, there have been many debates in the Netherlands about what student teachers should learn (HBO raad; 2009). Similar discussions have recently been held in the UK (Mitchell, 2011). The main line of these discussions is that teacher education should focus on the development of general pedagogical knowledge (PK), as well as the development of content knowledge (CK) and pedagogical content knowledge (PCK), instead emphasizing on the development of general pedagogical knowledge (PK). This dissertation supports the arguments for increased attention on knowledge development in the CK and PCK components of the teacher knowledge basis. We have seen that teachers generally find it difficult to stimulate deep geographic learning, and that this teaching difficulty is related to a lack of knowledge about how to translate geographic subject knowledge and geographic inquiry knowledge into knowledge for use in educational settings, and a lack of knowledge about how to use such constructs to structure, correct, and expand students’ geographic thinking via dialogical teaching, and in such a way raise it to a higher level. The question is: How much attention is paid to the development of this knowledge in teacher education? Perhaps teacher education should focus more on the question how to transform domain-specific knowledge so that it becomes accessible for students. It is advised to spend considerable time on deepening student teacher’s knowledge on several subjects (e.g. ‘climate change’ and ‘migration’) and transforming this knowledge to theories for use in educational settings. In addition, student teachers should investigate the relationships between those subjects (e.g. how climate change influences migration), and in such a way learn to see the world as a system. Furthermore, teacher education should perhaps focus more on the nature of geographic thinking operations, and on the role of the geographic language in learning to think geographically. It is advised to spend considerable time on constructing models for important cognitive geographic thinking operations, such as ‘identifying relationships in maps’ (see Figure 5-12 and Figure 5-13), on diagnosing problems when students work on task in which they have to apply these operations, and on exploring how to shape support interventions to guide students into selecting the right sub-operations, and into performing these sub-operations well. In this way, teachers learn how to guide students into performing these operations in a step-for-step manner.

13.2.3 Recommendations for further research

This is one of the first studies ever conducted on how to teach geography with GIS. It can therefore be seen as a pioneering work. The study provided some insight into the complexity of this educational innovation problem, and gave rise to many questions. Now follow some recommendations for further research.
First, little is known about the characteristics of optimal teacher training programmes that aim to train student teachers in stimulating deep geographic learning. Future research should focus on the question how to train student teachers and in-service teachers in reorganizing their knowledge about geographic subjects and geographic inquiry methods and transforming it so that it becomes accessible for students. Future research should also be conducted on the question how to train student teachers and in-service teachers in structuring, correcting, and expanding students’ geographic thinking via dialogical teaching. Specific attention should be put on guiding students into performing cognitive geographic thinking operations in a step-by-step manner, especially when it concerns identifying relationships in maps. A design research approach is recommended for such research. Together, teacher trainers and researchers could design, test, and evaluate teacher education programmes, and in such a way generate design principles for an optimal design for such programmes.

Second, we should do more research on GIS in secondary geography education. Future research should focus on the characteristics of an optimal design for short (one-lesson) modules with WebGiSs, as they hold great potential for geography education. In addition, we should do more research on the characteristics of optimal learning trajectories, from primary education to secondary education, of learning with GIS. Last but not least, we need to have more proof for the effectiveness of GIS-supported geography education.

13.2.4 Main assets of the practical part of the dissertation

So, what are the main assets of the practical part of the dissertation? For educational practice, the main asset is that it provides design principles for GIS-supported geographic inquiry projects, which can help teachers design and conduct similar projects. In addition, the practical part provides insight into the nature of the challenges for teachers to provide optimal coaching, and makes a number of recommendations for the content and set-up of teacher education programmes. This can help teacher trainers to shape their educational programmes.

For educational science, the main asset is that the practical part links a rather abstract theoretical ideas about the nature of GIS-supported geographic inquiry and rather abstract competency frameworks to educational practice. The practical part shows how the model and frameworks can be used to design GIS-supported geographic inquiry projects, and to understand how GIS-supported inquiry-based geography education works, and how the output of this kind of education can be raised to a higher level. Finally, the practical part has provided insight into the complexity of the educational innovation problem, and has provided some recommendations for further research.

13.2.5 Some final thoughts

In the past few years, important work has been done on providing an infrastructure for teachers in terms of software, geodata, and instruction materials. In addition, there is now an increased interest in the development of knowledge in the geo-CK component in teacher education programmes. As these developments continue, we can see a bright future for secondary geography education. However, the educational innovation of GIS-supported inquiry-based education should not be imposed on teachers with a lot of pressure. Instead, it should occur in a step-by-step manner.
14 References


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