Changes in Geo-information education, looking back and forward

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Key words: education, changes, history, future

SUMMARY

Looking back at a career of more than 35 years in GI education at the edge between the developments in society, work field and in education itself, the only consistency is change.
The most important changes during this period are discussed. Also, a look at the expectations and how these changes can be implemented in formal and informal education are mentioned.
Looking back there are at least 4 changes. In the end of the eighties almost no formal Geo-information education was existing. Digital data was slowly growing, but mostly in the process of conversion of analogue to digital, so no direct digital data collection. Software was not accessible without following a steep learning curve for people that had a logical, programming directed mind with a high effort. Practical applications were sparse, mostly in a scientific environment.
Expectation of possible changes in the next 5 to 10 years are a torrent of available data, integration of spatial solutions in most work processes, a need for more people which can combine domain knowledge with a geo-information approach (spatial thinking) and a diminished need for geo-information specialists.
What will these changes mean for the actual GI education?
Regarding the increase of available data, the emphasis will change from searching for data to assess the quality and correct application of the data for a specific use. Background how the data is collected, understanding the selection process and use of information models will be more important. Education should bring these higher levels of data into the curriculum by e.g., using cases, not only directed at a solution but also at the quality of the answer.
Data driven work processes are increasing. These processes do not ask for a total GI software but specific blocks of code. The integration of dashboards is an example.
Within work processes a team of people is active with different competences. So, the domain of the work process asks for people to have both knowledge regarding the domain, but also insight and work with data, analysis, visualization and sharing the results. Geo-information specialists like programmers, people with IT security expertise will be connected to such teams. They need to integrate their skills and tools inside the work processes.
The conclusion is that education should be even more integrated with real-life outside academia. The world and the Netherlands see large challenges, almost all with a spatial component. Our education should deal with these.

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1. INTRODUCTION

During a career of more than 35 years in Geo-Information (GI) education, it is a privilege to look back and forward. Changes are abundant in real life. And these changes will also affect education. This paper will look back but also give a personal view on the future of GI education.

2. CHANGES

During the 35 years of involvement, I see four major changes: from non-formal GI education and mostly training in software towards formal accredited education at different levels; the increase in the availability of (digital) GI data; from complicated software to more user friendly software and not the least the change from local to internet based work

2.1 Education

Major change is that the education moved from an informal to a more formal structure. Many short "introductions in GIS were followed by longer, more intensive and wider approaches of GI education" and became programmes of sometimes a 4-year Bachelor and Master courses. Emphasis moved from training software to more conceptual philosophy. Also during the eighties of last century, the first GI education books started to appear. E.g. Peter Burrough's *Principles of Geographical Information Systems* in 1986. Sometimes the books related to more educational material on a website e.g., Ian Heywood et al *Introduction to Geographical Information Systems* in 1998. It seems that the number of specific printed general education textbooks is decreasing. Reason for this could be that so much is already available in a digital format.
The number of tutorials related to specific domains of applications increased rapidly. E.g. *GIS tutorial for Health* of ESRI Press is a nice example, and updated for a new release of the software.
An important milestone was the publication of GIS&T Body of Knowledge in 2006, also available now in an updated digital version at UCGIS https://www.ucgis.org/gis-t-body-of-knowledge. The book and website gives the result of many discussions what could be needed for thorough competencies (knowledge, skills and in less detail attitudes). Clearly not everything is necessary to teach, but some overview and selection is possible.
Starting with GI education is done by teachers without a formal education in GI. Quite often the only drive was a general spatial interest. In some countries this comes from a geography background, in other cases IT and/or geodesy was the push and pull factor. All the time the

lecturers learned by doing. Nowadays more people have a formal GI education, combined with didactic experience.

2.2 Data

The amount of digital data increased enormously in this period. Nowadays estimation of 175 zetabytes in 2025 are common (Zinieris, 2023). Digitizing existing analogue paper data to a digital format with help of a digitizer or later scanner was most important in the eighties and nineties. The steps to directly collect data in a digital format came from the development of hand held systems with easy to handle software and useful for fieldwork. The availability of GPS since 1983 makes the relationship between data in the field with data in the office more useful. Another change regarding to data is the availability of portals, so that data can be searched, found and shared. Portals are in different forms e.g., more general like a country portal or continent wide like INSPIRE (https://inspire-geoportal.ec.europa.eu/). Also it can be more specific from a vendor like ArcGIS Living Atlas of the World (https://livingatlas.arcgis.com/en/home/) or a more statistical approach like the SDG Global Database (https://unstats.un.org/sdgs/dataportal).
Major problem related to the data is lack of reliable meta data. A clear view on the quality of the data, so that a relative lay-person can assess if the data is "fit for use". Also, the privacy discussion is important. Geo data ethics should be incorporated into the use and availability of the data.

2.3 Software

According my view the most important change is in the software. The energy and perseverance to use software in the eighties and nineties is much more compared with the software available now. The use of wizards and user friendly, context oriented software compared with the textbased lines is enormous. Help is more easily available, and most of the time in a digital form. Also many communities are useful e.g. the QGIS community (https://blog.qgis.org/tag/qgis-community/). Not only the easier interface is a change, also the movement from desktop to cloud and services. This makes that the amount of users has increased from GI specialist to end-users including citizens. Also pupils make fun and will be educated by using apps, that are downsized to a specific process. A critical point can be made that the easier the buttons are, how less understandable the outcome of an analysis can be. If you had to wait 2 days before a DEM was finished, you thought more intense about the choices of the different algorithms.

2.4 Internet

Overall, the major change in education and society is the availability of the internet. This makes the exchange of data and information much more easy, although only in the middle of the nineties it became more common and not overall in the world. I started the work in education, end of the eighties with only 10 email accounts for the whole university of 150 staff and 1400 students. And we had to use a slow modem. Hypertext made it easier so that programming was not necessary. The other side of the coin is that sometimes software will

not work properly without internet access. All by all, the GI community is more connected to each other. But it also asks for more structure to see behind all the bits and bytes.

2.5 Overview

In table 1 a summary of the developments is given. Outside education the organization of GI becomes more important. Although GI is during the whole period used in the form of projects, also other more organization wide applications is growing. Even societal use (without really knowing that GIS is in the background) increases. Especially the development of Google Maps since 2006 brings mapping to the whole population. The integration of GPS in the mobile phones is also pushing the use.

Aspect	**1990 - 2000**	**2000 - 2010**	**2010 - 2020**	**2020 – 2030?**
Knowledge	Raster/vector	Standard data models, IT > Geo	General and specialisations	Integration with domains
Skills	Desktop gis and programming	Development Web GIS	VR/AR	Diverse, (Geo) AI. Different app's
Attitude	Solo,	Curiosity	Communicative Creative	Lifelong learning
Data	Analogue to digital with digitizer	Mobile, field collection	Explosion Crowd sourcing Sensors	Structured and unstructured. Everywhere
Organization	Only projects, ad hoc use	Individual → GI department	GI department → information wide Citizen science	Teams and society wide use (without visible GI)
Education	Training, no formal end terms	Training → education	Formal and e-learning	Flexible and adaptive

3. FUTURE

Although looking back can help to understand the actual situation, it is more important to look at the future. What will be the effect of the trends to the content of GI education? A major aspect is that GI competencies will not be the same for all students. If the trend to learn via projects is increasing, education must be more flexible and specific for the interests of the students. Projects are more often team work that ask for specifics and general communication. In figure 1 the different profiles are given. So in education we have to develop the direction a student would like to go: a more generalist, aimed at the connector/project manager of the team or more the specialist with specific knowledge and expertise in a topic like database management, analysis, visualization or programming. The development of the student

depends also on the job, so perhaps as a junior it is not yet evident which direction they will go.

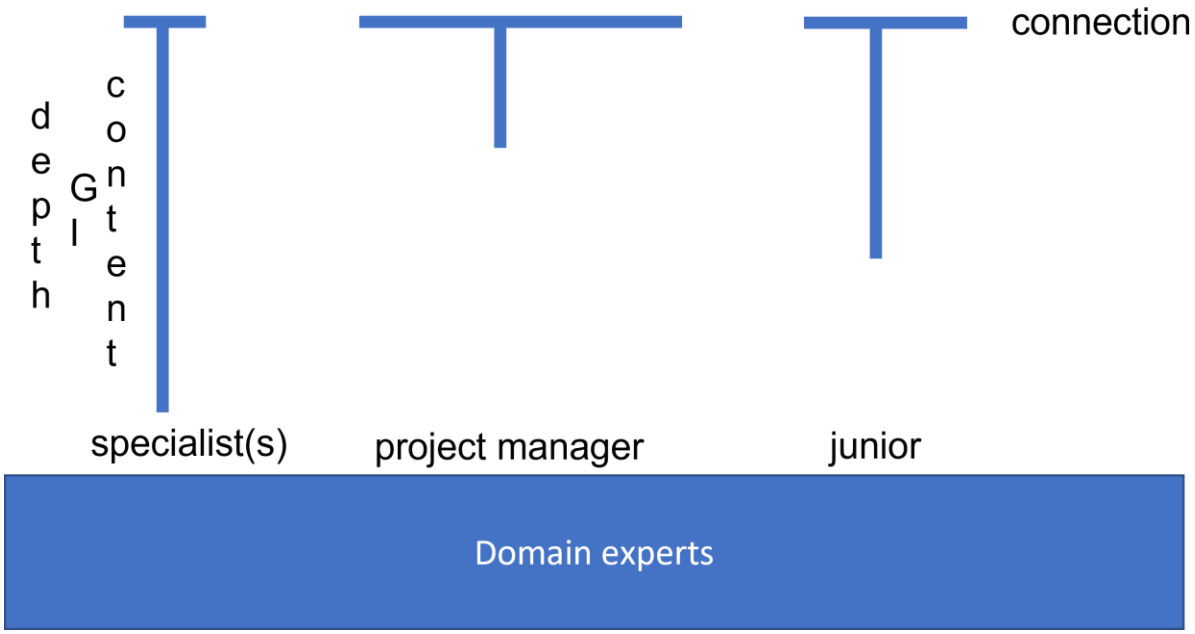

Figure 1 Overview of competencies in a project team

Due to the relative increase of use of non-purely educated GI people, it can be expected that in many domains like economy, history, medicine the use of GIS or spatial oriented software will flourish. In many projects (especially in AGILE methodology) the integration of domain knowledge with spatial specialist will become normal. Island approaches are too expensive. Often management defines the GI specialism as a costly branch. Added value comes from the solution of the questions. Expectation could be that the integration needs will also the change the "only GI questions.

4. CONCLUSION

Looking back and forward at GI education and the GI working world one thing is common. Dynamics are always happening. This means that flexibility in education and content is necessary. Updating the courses, learning students to adjust gives the luggage for Lifelong Learning.

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BIOGRAPHICAL NOTES

Marinus de Bakker is active for more than 35 years in geo-information education, mostly in regular Higher Education at different Institutes in the Netherlands and as visiting professor in different countries. Als he is involved in short courses for GI professionals on the job (waterboards; local and regional government; engineering and consultancy firms). His research is mostly aimed at the needed competencies for good, reliable and transparent use of geo-information. He organized with many others the FIG working week 2020/2021 and for 20 years the European Geo-Information System Education Seminars (EUGISES).

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