

Recognising Subgroup Requirements to Advance Digital Geomedia Use in Non-formal Education

Discussed by the Example of Non-formal Education for Sustainable Education

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Abstract

Users of geodata, digital geomedia and Geographic Information Systems form a highly diverse audience. Their roles range from technical experts to general users, and they come from different disciplines such as natural and social sciences, planning as well as education. Due to their different roles, backgrounds and skills, users have different needs that require the provision of user-centered geospatial products that also include supporting materials. The literature emphasizes that for successful use of geo-products, the target group and its sub-target groups must be identified and their requirements considered. This is particularly important for those for whom the use of geodata, digital geomedia or GIS is not a central aspect of their work, as is the case, for example, in non-formal education for sustainable development (ESD). But do subgroups of ESD-practitioners differ in their digital geomedia use, and how can their needs be considered? These questions are being investigated within the ESDplus project, which aims to promote the use of digital geomedia in ESD. An online survey among ESD-practitioners in German-speaking countries and several workshops with ESD-practitioners allowed to characterize different subgroups based on their digital geomedia use in ESD and to develop subgroup-centered recommendations for tailored information provision and training to support the integration of the use of digital geomedia in ESD. The findings obtained are also important for the development of other subgroup-centered geo-products relevant to GIS-laypeople like geoportals.

Keywords:

success factors, geomedia skills, user-centered training, user-centered information

1 Introduction, research question

Users of geodata, digital geomedia and Geographic Information Systems (GIS), i.e., geoinformation (GI) technology, represent a highly heterogeneous group (Locher, 2019; Muenchow et al., 2019). First, this refers to different roles that users can take on, from technical specialists to general GI users (Berry, 2007; Locher, 2019; Rickles et al., 2017).

Second, users come from very different disciplines such as social and natural sciences, planning, conservation, law, policy, health, and education (Kurniawan et al., 2023; Locher, 2019; Rickles et al., 2017). It also includes public users who use GIS for personal purposes and to fulfil civic duties (Król et al., 2024; MapMe, 2024; Muenchow et al., 2019).

Depending on the user group, their role, background and GI competencies, users have different needs on geo-products including supporting materials (Komárková et al., 2009; Kurniawan et al., 2023). Bartling et al. (2021) emphasize the importance of identifying and characterizing not only the overall target group but also subgroups distinguished, e.g., by their GI competencies. The development of subgroup-centered geo-products together with supporting materials is particularly relevant for disciplines where GI technology use is not a core component but (can) serve as a valuable tool. Examples are disciplines involved in Public Participation GIS, Participatory GIS and (Geo)Citizen Science initiatives (Golumbic et al., 2019; Hennig et al., 2022; Kurniawan et al., 2023; Yu et al., 2020).

This also applies to the educational sector (Raschke & Karrasch, 2018), where the relevance of using GI technology is underlined by approaches such as Spatially Enabled Learning (Vogler et al., 2025) and Spatial Citizenship (Gryl & Jekel, 2012). These frameworks highlight the pedagogical benefits of GI technology, including enhanced teaching effectiveness and the introduction of new learning dynamics through spatial context and visual representation. Moreover, the integration of location, i.e., space, (can) serve as an interface to additional information (Vogler et al., 2018).

The use of GI technology in education is closely linked to the concept of digital geomedial. It reflects the digital transformation of cartography from static representations of spatial information (e.g., traditional maps) to platform-based systems that dynamically connect users and information via location as an interactive interface (e.g., interactive digital maps; Traun et al., 2013). Digital geomedial encompass a wide range of media with spatial references that enable users to capture, create, store, process, analyze, visualize, and interpret geographical phenomena based on geodata. They facilitate the exchange of information and promote networking and collaboration between people (Gryl & Jekel, 2012; Thielmann et al., 2012). Examples are location-based games (e.g., Geocaching), web mapping tools (e.g., Scribble Maps), virtual globes (e.g., Google Earth), data collection apps (e.g., GPS-Essentials), open data including volunteered geographic information (e.g., OpenStreetMap), and data visualisation tools like interactive web maps and story maps (Diamond, 2015; Schmid, 2018).

Digital geomedial hold considerable, but in many cases untapped, potential for education, especially for education for sustainable development (ESD). As highlighted by Vogler et al. (2018) with respect to the SEL approach (Spatially Enabled Learning), embedding digital geomedial in an educational context introduces a new dynamic of learning and means an improvement in teaching effectiveness. This is because digital geomedial bring supporting spatial context and spatial representations create a special type of dual encoding by spatial contextualisation of contents. This can enhance learning arrangements including communication. Moreover, experiences and opportunities given by digital geomedial use relate

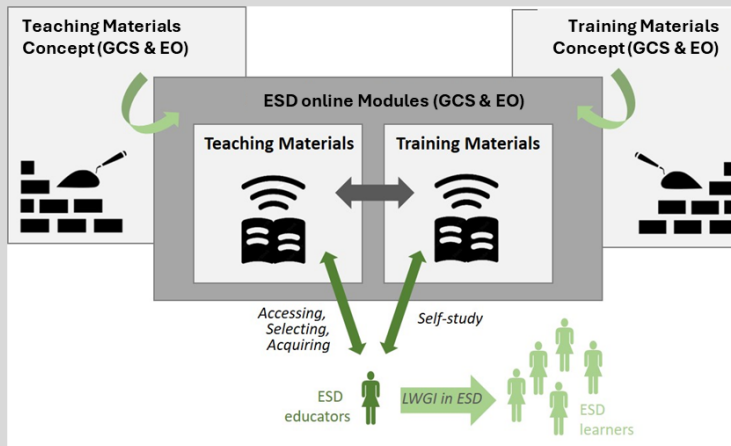
to “learning by doing” and the provision of an interface between physical and digital space. Further, working with spatial data using different methods and tools can deliver new, engaging and interesting insights in the topic under consideration – and this not only through nationalisation but also through the learners’ own active engagement (BMBWF, n.d.; Vogler et al., 2018). Not to forget, the public considers (digital) geomedial as a motivation and excitement factor (Passey et al., 2004; Vogler et al., 2018).

Referring especially to ESD and its aims, digital geomedial use brings several additional benefits (Anunti et al., 2023; Buck et al., 2022; de Lázaro-Torres et al., 2023; Giardino et al., 2014; Mohammadzadeh, 2019; Pokojski et al., 2018): Examples are to enhance awareness on environmental and ecological issues, promote critical thinking, facilitate transformative action among learners, foster sustainability practices and community engagement, and increase location awareness and convergence for ESD initiatives.

The aim of ESD is to raise awareness, motivate and empower individuals to adopt more sustainable behaviours. Often carried out as non-formal education, ESD is intended to offer learners a holistic perspective by integrating economic, social, and cultural dimensions. This is based on the acquisition of new knowledge, skills and values that are essential for shaping a more sustainable future (Ermakov et al., 2019; UNESCO, 2017; UNESCO, 2018). Like other educational approaches, ESD draws on aspects from problem-based, project-based and active learning as well as a learner-centered combination of methods and tools (ALPARC, n.d.; Zorenböhmer et al., 2022).

Advances in information and communication technologies and the accelerated digitalisation of society (among others reinforced by the COVID-19 pandemic; Dhawan, 2020; Zancajo et al., 2022) require changes and further developments in ESD (Hennig et al., 2024; UNESCO, 2013, 2017). For this, the relevance and potential of digital geomedial as well as the new possibilities for education are underlined (de Miguel Gonzalez, 2012; Ehlers et al., 2013; Fauville et al., 2013; Lude et al., 2013; Referowska-Chodak, 2020). A detailed understanding of ESD-practitioners is essential for developing suitable geo-products and supporting materials, as has already been demonstrated in terms of formal education and teacher training (Lindner-Fally & Zwartes, 2012). This raises several open questions: Besides considering the overall target group, can we also distinguish different subgroups of ESD-practitioners based on their digital geomedial use and skills? If so, what subgroup-specific requirements exist and how to address them? These questions are addressed based on findings from the ESDplus project (Box 1).

The ESDplus project (April 2023 – September 2025; <https://esdplus-zgis.hub.arcgis.com/>) is funded by the Earth System Sciences program of the Austrian Academy of Sciences. In cooperation with the Lungau Biosphere Park (Austria) and the Berchtesgadener Land Biosphere Region (Germany), the project aims to promote the use of digital geomedias in non-formal ESD. For this, ESDplus pursues three main goals: (i) developing a concept for teaching materials that enable ESD-practitioners to use digital geomedias independently and flexibly, (ii) creating a concept for training materials to familiarize ESD-practitioners with digital geomedias to apply in ESD, and (iii) designing and implementing all ESDplus materials as online resources. This results in three modules: two teaching modules - one focusing on crowd mapping (i.e. Geo Citizen Science GCS) and one on the use of Earth Observation (EO) data and tools - and one training module to prepare for digital geomedias use in ESD. With this, throughout the project duration, ESDplus addresses the three overarching objectives: (i) providing a practical foundation for the use of digital geomedias in ESD, (ii) offering a theoretical framework to support its integration in ESD, and (iii) fostering a community of ESD-practitioners who already use or are interested in using digital geomedias in their ESD practice.



Box 1: Overview of the ESDplus project

2 Methods

By applying different methods, we were able to identify and characterize different groups of ESD-practitioners in terms of the extent of their digital geomedias use in ESD (Figure 1). Based on this, recommendations on how to address the needs of the different groups were developed.

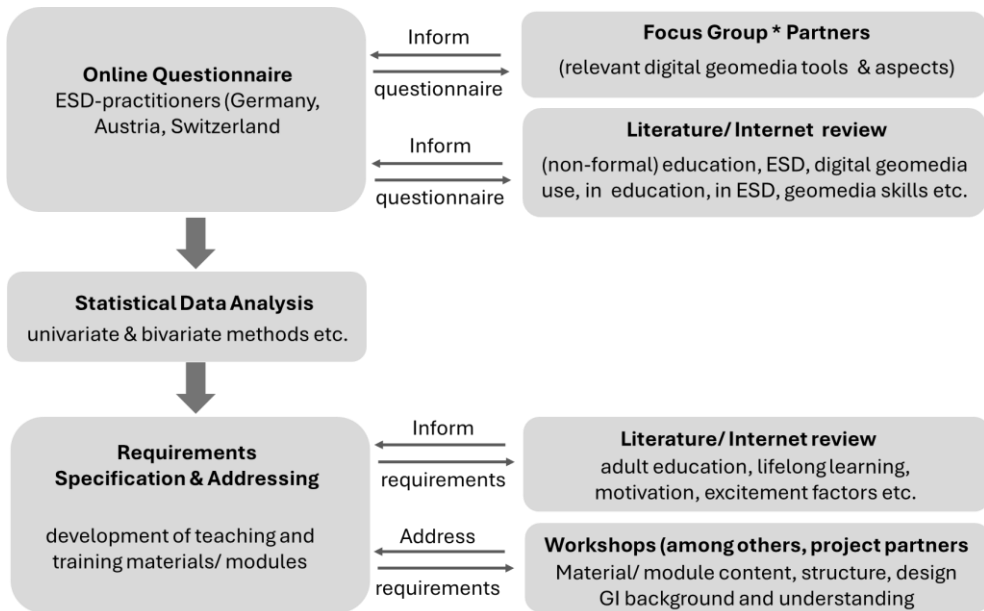


Figure 1: ESDplus workflow

To gain insights into the use of digital geomedia in ESD and to determine the varying use extent, an online survey was conducted among organizations that carry out non-formal ESD in Germany, Austria and Switzerland. This contains zoological gardens, environmental education centers, nature conservation associations, natural history museums, protected areas (e.g., national parks, nature parks, biosphere reserves) and non-governmental organizations. The questionnaire was distributed by email to approximately 1,400 organizations in autumn and winter 2023/2024.

The development of the questionnaire was informed by a focus group with all partners as well as review of literature and online sources (selected literature used is available on the ESDplus Website: <https://esdplus-zgis.hub.arcgis.com/pages/dissemination>, i.e. Hennig 2023). This enabled, among other things, the identification of relevant digital geomedia tools and aspects to be questioned. The survey was created in accordance with the principles of empirical social science research (e.g., Callegaro et al., 2015) and implemented using the free online survey tool LimeSurvey. The questionnaire was improved based on feedback from cognitive walkthroughs and pre-tests (conducted with the project partners), which are well-established and well-known methods in questionnaire design and empirical social research (Callegaro et al., 2015; Hilton 2015). The finale version consisted of 14 questions (Figure 2; <https://esdplus-zgis.hub.arcgis.com/pages/mitmachen>, i.e..

<https://zgis.maps.arcgis.com/sharing/rest/content/items/a372c04254d84762ac7cb87c3ea6378a/data>). The questionnaire responses were statistically analysed using R/RStudio using univariate and bivariate methods (e.g., cross-tabulation analysis using Fisher's exact test/ chi-squared test; Bamberg et al., 2012).

Contact information	• Organization name (Open question; short text) • Email in case of interest to receive results (open question; short text)
Assessment of digital geomedial use	• Statement agreement of digital geomedial use (closed question; 5 point choice) • Barriers regarding the use of digital geomedial in ESD (closed question; multiple choice) • Opportunities for support (closed question; multiple choice)
Current situation of digital geomedial use and knowledge	• Level of digital geomedial use in ESD (1: none to 5: high) • Tools used and/ or known (closed question, array/ multiple choice) • Familiarity with terms and concepts (closed question, array/ multiple choice) • Activities carried out related to digital geomedial (closed question, array/ multiple choice) • Topic areas for digital geomedial use in ESD (closed question; multiple choice)
Personal experiences, recommendations etc.	• Sources of information used with regard to ESD (open question; long text) • Added value of the use of digital geomedial in ESD (open question; long text) • Best practice examples known (open question, multiple short text) • Examples of the use of digital geomedial in analogue ESD (open question; multiple short text)

Figure 2: Overview, i.e., structure and content of ESDplus Questionnaire

To understand and complete the questionnaire results, the findings from an additional literature and Internet review were used (compare Hennig et al. 2024; Figure 1). In addition, six workshops with 6–10 participants each were held in 2025 (Table 1). The participants came from regional ESD organisations, including the project partners. During the workshops, how to address challenges and problems of using digital geomedial in ESD was discussed. This allowed for further insights into the knowledge and understanding of ESD practitioners regarding GI tools and aspects, as well as GI terms and concepts. This took place on the use and evaluation of the ESDplus teaching and learning material prototypes. Recommendations were made on how the identified subgroup requirements can be considered.

Table 1: Information on ESDplus Workshops

Workshop (WS)	Focus/ Results	Date of the event	Number of participants
Geo Citizen Science 1 + 2	• Mapping activities, GPS, and cartography • Use of tools and embedding in ESD	11. October 23	10
		7. March 24	11
Earth Observation 1 + 2	• Background and basics of EO • Use of tools and embedding in ESD	20. October 23	11
		21. March 24	14
Train the Trainer 1 + 2	• Understanding knowledge and needs on GI terms and concepts on part of GI practitioners • Addressing needs on GI terms and concepts on part of GI	4. December 23	14
		11. April 24	12

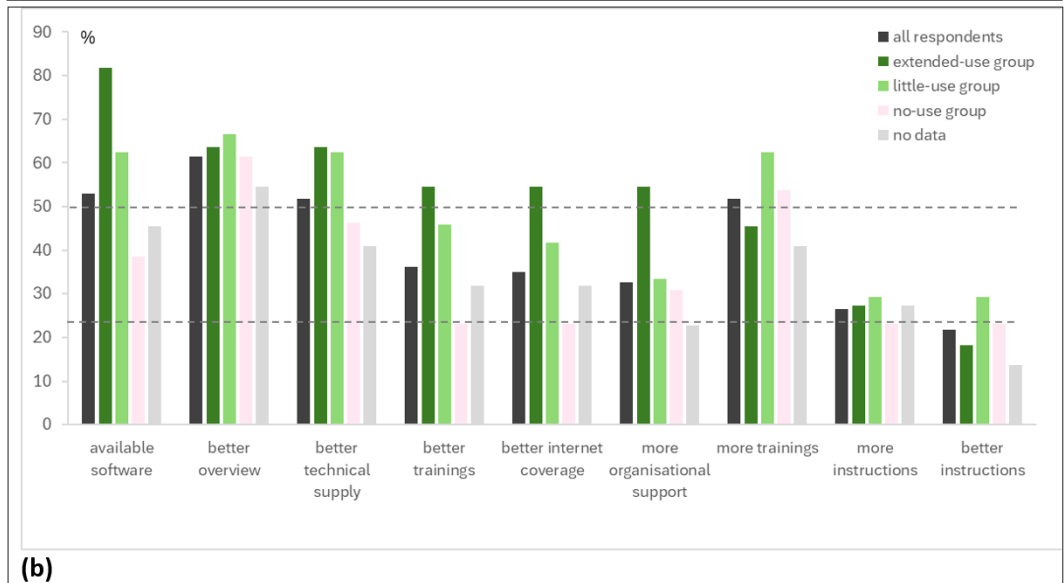
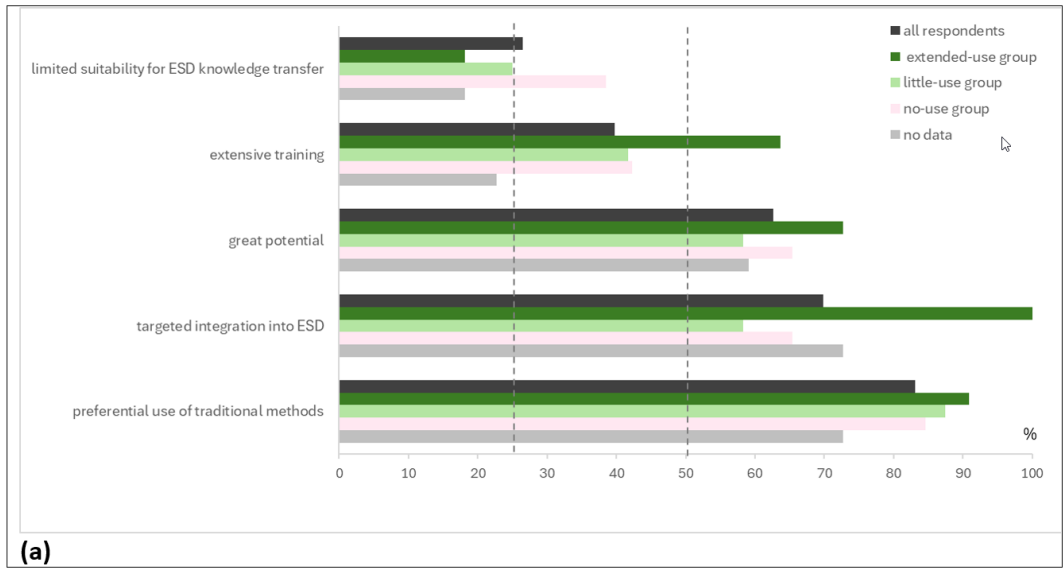
3 Questionnaire results

The questionnaire resulted in 83 responses, although 239 people accessed the questionnaire. This is because in LimeSurvey responses are only available when questionnaires have been actively submitted by pressing the final “Submit” button. With a response rate of 6%, this is still within an acceptable range, as discussed in the literature (e.g., Le Masson, 2025).

The results show that digital geomedial use varies greatly among ESD-practitioners. Only a small proportion of respondents reported using digital geomedial to a large extent (4 %) or to some extent (10 %). Most ESD-practitioners do not use digital geomedial (31 %) or only use it to a limited extent (29 %); 26 % of respondents did not answer the question. Based on respondents’ extent of digital geomedial use in ESD, four groups are distinguished: (i) non-use (31 %), (ii) little-use (29 %), (iii) extended-use (13 %), and (iv) no data (n.d.; 26 %).

3.1 Agreement with statements, barriers and support opportunities

Although 63 % of respondents see great potential in digital geomedial use in ESD, and only 27 % see limited suitability for ESD knowledge transfer (Figure 3a), many remain sceptical about this and most prefer traditional, i.e., non digital, analogue methods (83 %). There is broad consensus on the need for a targeted integration of digital geomedial into ESD (70 %); 40 % stress the need for extensive training. Figure 3b shows that main support opportunities are to have a better overview of digital geomedial including its use in ESD (61 %), provision of software (53 %), more trainings (52 %), and better technical supply (52 %). Around a third of respondents see better trainings, better internet coverage, and more organisational support to be important; more and better instruction are least relevant (27 %, 22 %). Among barriers surveyed (Figure 3c), number of trainings (47 %), technical requirements (i.e., the organisation's technical equipment; 46 %), and cost/ availability of software (45 %) are the most important. Additionally, 39 % of respondents consider (missing) available information as a barrier, 30 % internet coverage and number of instructions, 29 % (missing) organisational support. Between the different groups (without n.d.-group) cross-tabulation analysis reveals no significant differences regarding statement agreement, support needed and barriers ($p > 0.05$). Nevertheless, certain tendencies can be observed within and between the groups: e.g., relevance of trainings and targeted integration into ESD for the extended-use group, need for information on part of the little-use group.



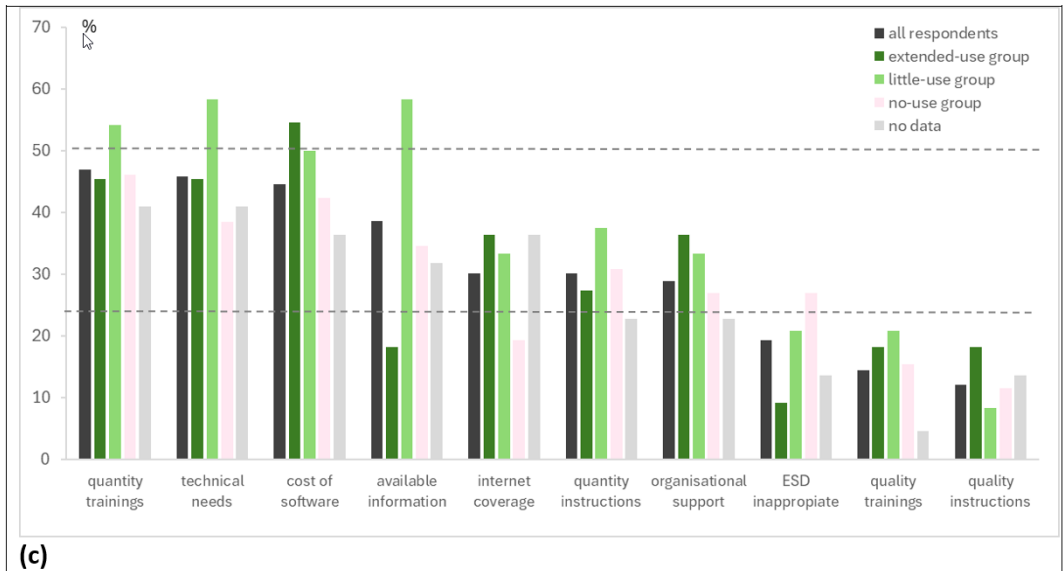


Figure 3: ESD-practitioners opinion (multiple choice; N=83): (a) Statement agreement, (b) Support opportunities, (c) Barriers

3.2 Knowing and using tools

The number of respondents who know and use digital geomedias varies greatly depending on the aspect (Figure 4a, b). Most respondents know Google Maps (94 %), Geocaching (90 %), Google Earth (87 %), and OpenStreetMap (81 %). Still more than 50 % of respondents outline to know Citizen Science approaches, ActionBound, Desktop-GIS, ArcGIS online, and tracking apps. Less than 50 % but more than 25 % of respondents mention to know Open Government Data, online mapping apps, Survey123, digital globes, and Copernicus data. All other aspects (geo quizzes, story maps, USGS Earth Explorer, Sentinel Explorer, Scribble Maps) are known by less than 25 % of respondents; Geo:spective, EO Browser, ESERO, and Maptionnaire are known by less than 10 %.

Between knowing and using digital geomedias, there are considerable differences. The number of known ones is – as expected – always higher than the number of used (Figure 4 a, b). Among ESD-practitioners, the most well-known and most used tools are Google Maps (64%), Google Earth (43%) and OpenStreetMap (40%). Certain use refers to Citizen Science initiatives (41 %), Desktop-GIS (34 %), ActionBound (28 %). Geocaching – although widely known (90 %) - is only used by 27 % of respondents. Less than 25 % of respondents indicate to use online mapping apps, Open Government Data, tracking apps, and ArcGIS online; less than 10 % to have already used digital globes, USGS Earth Explorer, Survey123, Copernicus data, story maps, Scribble Maps, geo quizzes, and Sentinel Explorer. No one has indicated that they use EO Explorer, Maptionnaire, Geo:spective or ESERO.

Using cross-tabulation analysis we find more significant differences between the groups ($p \leq 0.05$; without n.d.-group) regarding the use of digital geomedial than regarding the knowledge of digital geomedial. The cross-tabulation analysis in terms of the known tools shows significant differences between the groups only for Open Government Data, tracking apps, and ESERO ($p > 0.05$; without n.d.-group). Regarding the other digital geomedial, there are no significant differences. As Table 1 shows, most respondents in the different groups are either familiar with the digital geomedial surveyed or not.

Cross-tabulation analysis regarding the tools used revealed significant differences between the groups for Google Maps, Google Earth, OpenStreetMap, Open Government Data, Desktop-GIS, digital globes, ActionBound, Copernicus data, ArcGIS online, tracking apps, and online mapping apps. In detail, of the extended-use group, more than 50 % of respondents use Google Maps, Google Earth, OpenStreetMap, Open Government data and Desktop-GIS. All other digital geomedial are used by less than half of respondents of the extended-use group. Considerably fewer respondents from the other groups use these aspects. For story maps, Scribble Maps, Geocaching, geo quizzes, USGS Earth Explorer, Sentinel Explorer, EO Browser, Citizen Science, Survey123 cross-tabulation analysis does not find significant differences, whereas across the different groups they are used by less than 50 % of respondents. Now, there is no tool that is used by more than 50 % of respondents in each group (Table 2).



Table 2: Overview of the current situation of digital geomedial use in ESD of respondents and groups (gray shaded: known, used by > 50 % of respondents in all groups; green shaded: known, used particularly by extended-use group members; red shaded: by 50 % of respondents in all groups)

	No differences between groups (crosstabulation analysis; $p > 0.05$; without n.d.-group)		Differences between groups (crosstabulation analysis; $p \leq 0.05$; without n.d.-group)
	> 50 % of respondents in each group	< 50 % of respondents in each group	
Digital geomedial known	Google Maps, Google Earth, Geocaching, ActionBound, OpenStreetMap, DesktopGIS, ArcGIS online, Citizen Science, online mapping apps	digital globes, story maps, Scribble Maps, geo quizzes, Copernicus Data, USGS Earth Explorer, Sentinel Explorer, EO Browser, Maptionnaire, Geo:spective	Open Government Data, Tracking Apps, ESERO (more by extended-use group)
	Survey123 for ArcGIS online (> 50 % extended-use group, little-use group)		
Digital geomedial used		story maps, Scribble Maps, Geocaching, geo quizzes, USGS Earth Explorer, Sentinel Explorer, EO Browser, Citizen Science, Survey123 for ArcGIS online, Maptionnaire, Geo:spective, ESERO	Google Earth, digital globes, Open Government Data, Desktop-GIS, ArGIS online, tracking apps (more by extended-use group)
			Google Maps, ActionBound, OpenStreetMap, online mapping apps (more by extended-use group, little-use group)
			Copernicus Data (more by little-use group)
Functions used	Online maps navigation	crowd mapping, use spectral channels	cartographic visualization, filter geodata, import and export geodata, ,, create geodata (digitize), spatial analysis (more by extended-use group)
	cartographic visualisization, implement online maps, share geodata, use satellite images (> 50 % extended-use group)		geoportals (data source), create geodata (GPS) (more by extended-use group, little-use group)
	measure, share geodata (> 50 % extended-use group, little use group)		transform coordinates (more by little-use group)
Familiarity with terms, concepts	digital elevation model, GIS, layer, GPS/ GPX, metadata, pixel	area of interest, Sentinel	geoportal, basemap, Web Map Services, KML/KMZ, Landsat, spectral channels, JPEG2000 (more by extended-use group)
	coordinates, georeferencing, heatmap, GeoTIFF, temporal resolution, orthophoto (> 50 % extended-use group)		
	geodata models, shape file (> 50 % extended-use group, little use group)		geotagging (more by extended-use group, little-use group)

3.3 Familiarity with functions, terms and concepts

Respondents are most familiar with the following terms and concepts (Figure 5a): GIS (77 %), GPS/GPX (77 %), pixel (75 %), metadata (65 %), and layer (63 %). More than 50 % of ESD-practitioners surveyed are familiar with geoportals, geodata models, coordinates, digital elevation models, and shape files. Less familiarity (< 50 % of respondents) is found regarding basemaps, georeferencing, geotagging, heatmaps, web map services, and KML/KMZ. This also refers to terms and concepts related especially to Earth Observation (EO): Landsat, JPEG2000, orthophotos, temporal resolution, area of interest, GeoTIFF, spectral channels, and Sentinel. Among the functions surveyed, most used (> 50 % of respondents) are online map navigation, geoportal use (data source), measuring, create geodata (GPS); 25–50 % of

respondents have experience with cartographic visualisation, online map implementation, filter geodata, export and import geodata, share geodata, create geodata (digitalise), spatial data analysis and satellite images. Less than 25 % of respondents have ever used crowd mapping, transformed coordinate and used spectral channels (Figure 5b).

Only online map navigation has already been carried out by more than half of respondents in each group. Respondents of the extended-use group make most use of the different functions surveyed (exception: measuring, transformation of coordinates; Table 2): More than 50 % of respondents already used the different functions surveyed, exceptions are crowd mapping (27 %), coordinate transformation (18 %), using spectral channels (9%).

Cross-tabulation analysis indicates significant differences between the groups regarding functions already carried out ($p \leq 0.05$; exclusion n.d.-group; Table 2). This refers to measure, filter geodata, use geoportals (data source), create geodata (GPS), import and export geodata, create geodata (digitise), spatial analysis, transform coordinates. Here, members of the extended-use group have most experience.

Comparable to the use of functions, familiarity with terms and concepts is highest in the extended-use group (> 50 % of respondents; exception area of interest, Sentinel). Significant differences between the groups (cross-tabulation analysis; $p \leq 0.05$; without: n.d.-group) exist on the following terms: geoportal, basemap, Web Map Service, geotagging, KML/KMZ, Landsat, spectral channels, and JPEG2000.

Even though the cross-tabulation analysis shows no significant differences between the groups for some of the concepts and terms surveyed, a differentiated picture emerges with regard to familiarity or unfamiliarity with terms and concepts (Table 2). Thus, terms and concepts known by all groups are GPS/GPX, pixel, digital elevation models, GIS, layer, metadata (> 50 % of respondents), not known are area of interest, and Sentinel (< 50 % of respondents).

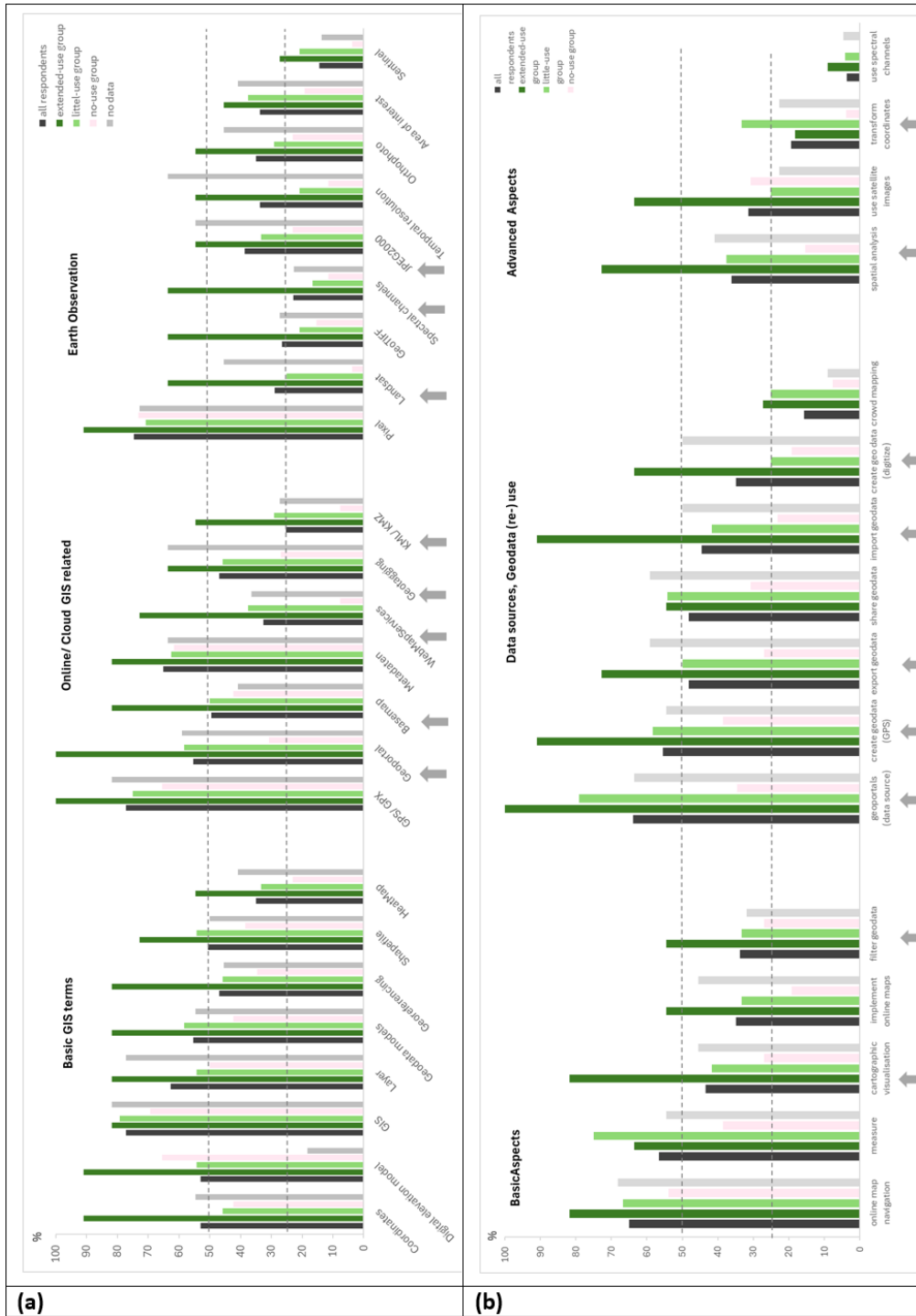


Figure 5: Familiarity with terms and concepts (a) and use of GI functions (b) (N=83; grey arrow: significant difference between the groups without n.d.-group, $p \leq 0.05$)

4 Discussion: Requirements and recommendations

The survey results show that all respondents and all groups have a certain level of GI knowledge and skills. However, when starting to use digital geomedial or promoting it in ESD, various aspects are crucial and must be taken into account. This involves providing information, offering training, and specifically promoting the integration of digital geomedial use into ESD. These aspects can be well addressed differently than internet coverage and organisational support, and they can support to face challenges such as cost, i.e., availability of software, and technical needs. The survey results show that these aspects have different relevance for ESD-practitioners or the respective group and require different subgroup-specific solutions and actions.

Awareness, interest, motivation

With most respondents preferring analogue geomedial over digital in ESD (Figure 3a), there is a clear need for more information across all user groups to increase awareness, interest, and motivation about digital geomedial use in ESD. The relevance of information is especially pronounced among the little-use group (Figure 3b, c) and the non-use group. They show the greatest scepticism towards digital geomedial use in ESD (i.e., limited suitability for ESD, Figure 3a). The perception that digital geomedial use is unsuitable for ESD is closely tied to insufficient understanding of its benefits, including existing possibilities. Like other digital tools used by laypeople, ESD-practitioners – to be open to the use of digital geomedial in ESD – need to be aware of the existing suitability and potential and have an interest in it (van Dijk, 2012; Hennig, 2019). Creating awareness, interest and motivation is the basis on which all other aspects, such as the further development of geomedial skills (i.e., training), can take place – and subsequently a greater use of digital geomedial in ESD.

This can be done by contributions in educational and ESD-specific conferences and journals, workshops and events, as well as forums, blogs, and other platforms that deal with ESD (Hennig et al., 2024). Since it has been shown useful if colleagues share and discuss their experiences with others (i.e., approach of peer learning; Fritz et al., 2017; Keerthirathne, 2020; van Dijk, 2012), building an engaged community can greatly support in advancing digital geomedial use in ESD. This offers the opportunity to reach ESD practitioners with little interest and a rather negative attitude towards digital geomedial use in ESD.

For raising awareness, interest and motivation – as outlined throughout the ESDplus workshops - the presentation of application examples of digital geomedial use in ESD is important. ESD-practitioners emphasize the showcasing of digital media use in the concrete context of ESD activities, including the tool-related and associated benefits. They are in line with benefits outlined in section 1. The provision of appropriate information using various categories of digital geomedial relevant in the educational context (Figure 6; Schmid, 2018) enables the overcoming of additional challenges. This involves (missing) software (Figure 3b, c) and (high) technical needs (Figure 3b, c) by showing, e.g., that open access and easy to use tools exist.

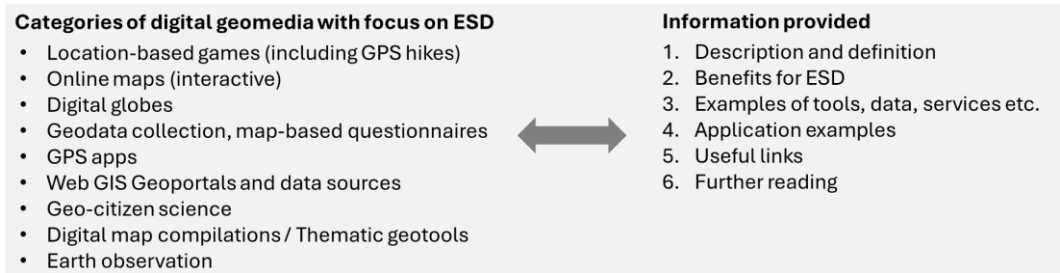


Figure 6: Application examples of digital geomedia use in ESD (see ESDplus team 2025)

Skills

Using digital geomedia in ESD, asks for certain skills. This makes training essential which is also reflected in the survey findings: Not only do more than the half of all respondents see training as an important support factor (Figure 3c), but also do the different groups view it as important (Figure 3a; Figures 3b). Further, a higher proportion of respondents from the extended-use group emphasizes the provision of better training as a supporting factor (Figure 3b).

In line with the concepts of adult education and lifelong learning (Detjen, 2007; EC, 2012; NP BNE, 2022; Vogler & Hennig, 2013), training for ESD-practitioners shall consider and build on experience with tools as well as existing knowledge and skills. The survey results reveal the following (Figure 4-6):

- Tools used in everyday life or in non-GI-specific disciplines (Rickles et al., 2017) are generally known to ESD-practitioners and are used at least by ESD-practitioners of the extended-use group. Examples are Google Maps, Google Earth, Desktop-GIS, ArcGIS online, GPS. Other tools - important for education - are generally unknown and not used by ESD-practitioners, e.g., story maps, Scribble Maps, and EO browser (Education Group, 2025; Dolenc, 2018; Tusam et al., 2024).
- All groups have certain GI knowledge and experience. This also refers to respondents from the non-use and the little-use group who have selected knowledge on terms and concepts and experience in performing GI-related functions. Regarding EO, they only have very limited knowledge, even though the relevance and suitability of EO data and tools for education and ESD is well-known (e.g., Asimakopoulou et al., 2023; Dannwolf et al., 2020; Schneibel & Siegmund, 2018).

Considering this fact and the findings from the ESDplus workshop, different aspects of training content and design for the different use extent groups of ESD-practitioners are shown in Figure 7. The aim is not only to prepare ESD practitioners for the use of digital geomedia in ESD, but also to develop them from non- and little-use to extended-use users. Extended-use ESD-practitioners should be encouraged to engage in self-directed learning and become multipliers for the use of digital geomedia in ESD.

Generally relevant aspects • focus on problem,- project-, action-based and peer-to-peer learning • highlight interesting, exciting examples with potential for use and transfer to own activities • all exercises, explanations, application examples etc. with focus on ESD • put practice first and theory second • option to access additional information in the case of interest (e.g. links to other courses, materials, tutorials) • consideration of motivational factors that act as success factors (e.g., design, content, structure, onboarding process)	
No-use/ little-use group • change situation from knowing to using tools, i.e. digital geomedial (in the context of ESD) • use of basic tools familiar to public users • introduce advanced, to the public unknown tools • completion and deepening of existing experience regarding GI activities and knowledge of terms and concepts, including existing basic skills and knowledge • build competencies and raise awareness on the use of EO data and tools in ESD	Extended-use group • Change situation from knowing to using tools (in the context of ESD) with focus on non-typical geomedial/ GI tools but particularly suitable for education • Focus on advanced terms and concepts • Refresh and strengthen knowledge and experience on advanced GI aspects (e.g. transformation of coordinates, crowd mapping) • raising awareness, interest and motivation for self-directed learning through the use of additional materials and tutorials for advanced GI usepromote and strengthen their role as multiplier

Figure 7: Considerations for training activities for the different digital geomedial use extent groups

ESD-objectives

Digital geomedial should be used to fulfil ESD-goals and not for their own sake (Hennig et al., 2024; Hiller et al., 2019). As highlighted by the respondents (Figure 3a), target integration of digital geomedial use into ESD is key. Even though this is primarily stressed by the extended-use group, it is essential for all groups, e.g., to face the opinion of limited suitability of digital geomedial use for ESD (Figure 3a). Findings from the literature review and ESDplus workshops reveal how to meet this need (Figure 8). What is key success factor important is fun. In addition to the development of teaching materials, i.e., instructions, this also applies to the development of information and training materials.

Content • always put examples first to raise awareness, interest and motivation (i.e., combine/support all content with simple, interesting examples incl. possibilities of adoption in terms of own activities) • always put ESD first: explicitly and clearly explain to ESD-practitioners how tools are/ can be meaningfully integrated into ESD • showcase exciting application and best practice examples in the ESD context • go beyond merely presenting digital geomedial and its use, instead focus on its use in the ESD (i.e., use of digital geomedial shall not distract from ESD but support it) • clearly demonstrate how digital geomedial use supports ESD-goals, i.e. enable ESD-practitioners to recognize the added value and specific potential of digital geomedial for advancing ESD objectives • show combination of analogue and digital materials and methods (i.e. digital geomedial) and how they complement each other for better ESD activities	Design • consider use of language (e.g. avoid technical terms) • reduce text to read to a minimum • combine different multimedia and interactions • attractive design • consider usability and accessibility criteria: e.g., simple and intuitive GUI, no unnecessary elements, suitable font size, color, symbols • integrate excitement factors (e.g. use of mascote, interactions, peer contact) • etc.
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Figure 8: Selected aspects for a targeted integration of digital geomedial use into ESD (based on ESDplus workshop findings, Detjen 2007; Hamilton 2016; Hennig 2019; Wilber 2018)

5 Conclusion, outlook

GI users represent a very heterogeneous group, as GI technology is used for different tasks and in different disciplines. This also includes users for whom the use of GI technology is not a central part of their work but supports it considerably. To develop indeed user-centered geo-products and supporting materials, it is necessary to consider not only the target group but also its subgroups characterized by different backgrounds and skills and so different needs and requirements. This refers also to non-formal ESD, for which – alike to education - digital geomedial open new possibilities. Since digital geomedial is still less used in ESD, a detailed understanding of ESD-practitioners and their perspectives and needs is crucial for its successful implementation in ESD. This is highlighted by findings from the ESDplus: Results from an online questionnaire directed towards ESD-practitioners in Germany, Austria and Switzerland underline the existence of different use extent groups (non-use, little-use, extended-use) characterised by different attitudes towards digital geomedial use in ESD and different geomedial skills. The results of the questionnaire illustrate the relevance of information provision, training, and the targeted integration of digital geomedial use into ESD. These aspects are of varying relevance to the different subgroups and must be addressed differently. Results of workshops with ESD-practitioners provide suggestions on how to deliver subgroup-specific information and training. They stress that we can build on certain geomedial competencies across all groups, but we must also face skepticism.

Now that subgroup-centered information, teaching, and training materials have been implemented in the ESDplus project based on the presented results, it is now necessary to promote their use and to evaluate the changes resulting from their use with regard to the situation of the use of digital geomedial in ESD. It must be emphasized that the results are relevant not only for ESD, but also for other areas where non-GI experts engage with GI technology. This refers, for instance, to geoportals which are widely used across many domains and the public. However, it must also be emphasized that the sample size of the questionnaire responses is very small and that the number of ESD practitioners who do not provide information on whether they use digital geomedial in their ESD activities is relatively high. Therefore, further research is needed for the continued and improved development of information and materials tailored to subgroups. The ESDplus project and the results achieved here can thus only be considered as a starting point for further work and discussions.

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