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Expressions of geographic literacy in the context of the COVID-19 pandemic: The role of geographic education among adults

Research Manuscript

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ABSTRACT

The global outbreak of COVID-19 brought an unprecedented influx of official and semi-official geographic information to individuals worldwide, primarily in the form of geospatial and numerical data. Maps specifically played a key role in the conveying of information and guidelines to the public in relation to the pandemic. Yet to fully understand such input, and reach informed decisions, the public needed to possess and utilize geographic literacy. In this paper, the term geographic literacy is defined as the ability to use spatial-geographic knowledge, skills, and reasoning, as a means for understanding and interpreting intertwined spatial phenomena. This study therefore aims at examining geographic literacy among adults, both in general and in relation to geographic education. Online quantitative questionnaires were completed by a representative sample of 456 Hebrew-speaking adults in Israel. Findings indicate low geographic literacy among the public, as seen in tasks that require data extraction and comprehension of visual representations. While the non-cognitive outcomes, such as attitudes towards geography and self-efficacy in geography, were strongly correlated with expressions of geographic literacy in the context of COVID-19, the highest formal instruction in geography and geographic education were not. These findings indicate that low geographic literacy might hinder making pandemic-related informed decisions, thus highlighting the importance of promoting geographic literacy. We conclude with the importance of identifying pedagogical mechanisms that enhance geospatial skills while also addressing non-cognitive outcomes, to better prepare diverse population for 21st-century challenges.

Keywords: Geographic literacy, geospatial literacy, geographic education, geographic knowledge, COVID-19.

INTRODUCTION

As individuals and as members of society, people must frequently make decisions relating to physical and human phenomena within a certain geospatial framework – such as choosing a place of residence or taking necessary precautions against natural hazards (Dolan, 2019). In such geospatial contexts, a range of geographic questions arise, regarding the meaning of these phenomena, as well as their location within the space, mutual interactions, spatial patterns, and shaping processes. To adequately address and deal with questions regarding geospatial phenomena, people must possess and apply *geographic literacy*, i.e., their ability to utilize geographic knowledge, skills, and reasoning, supported by critical and creative thinking (Dikmenli, 2014; Dolan, 2019; Edelson, 2013, 2014). Yet little is known about how adults apply geographic literacy in their everyday lives. This research focuses on adults' geographic literacy in the context of the COVID-19 pandemic.

Geographic literacy includes geographic knowledge and skills for using geographic tools, and geographic perspectives; yet to employ these abilities, in both every day and unique environments, *geospatial thinking* is also needed. This cognitive skill involves understanding the nature of the space, through geospatial concepts, geospatial reasoning processes, and methods that are used to represent and convey geospatial information (Bednarz & Lee, 2018, 2019; Jo, 2018; Kerski, 2015). Within a geographic context, spatial thinking is used to recognize and understand spatial patterns, differences, effects, and associations (Jo, 2018; Bednarz & Lee 2018). Studies have examined specific applications of geospatial thinking among school and university students (Bednarz & Lee 2019; Carbonell-Carrera et al., 2020; Xie, Zheng, Sun, et al., 2021; Xie, Reader, Vacher, et al., 2021), yet how do adults apply geospatial thinking when engaging in real-life scenarios and risks?

In terms of education, geographic literacy includes understanding the interactions, interconnections, and implications of various spatial concepts (Edelson, 2014), while

integrating them with the ability to understand, process, and utilize spatial data (Turner & Leydon, 2012). Specifically, *geospatial literacy* relates to the ability to extract information from a given geospatial representation and to understand and relate to spatial phenomena (Moorman, 2019). Hence, geographic and geospatial literacy are strongly coupled with critical geospatial thinking, which is vital for conducting geographic decision-making processes (Desouza, 2021; Stoltman et al., 2017). In this paper, the term *geographic knowledge* is assumed to also include the term *geospatial knowledge*, as the former is embedded in the latter, and bilateral relations exist between the two (Golledge, 2002).

Geographic literacy also provides cognitive tools for understanding physical information and human activities (Ikhsan et al., 2018). It includes the ability to analyze geospatial patterns and processes, while establishing critical thinking about how they are interconnected. As such, geographic literacy promotes the understanding of various physical and human phenomena, enabling problem resolution and informed decision making. Such literacy is of growing importance, due to the ever-increasing use of geospatial technologies in our day-to-day lives. These technologies include digital maps, visual illustration aids, and advanced sensory devices that utilize real-time location data, such as global positioning and geographic information systems. Today, these technologies play a significant role in determining public policies and in personal decision making.

The global COVID-19 pandemic further increased the public's need for geographic literacy, especially in relation to the spread, intensity, and infection levels of the virus from a geographic point-of-view. Social vulnerability, in light of the pandemic, emphasized the importance of geographic literacy, with a focus on social responsibility and communal resistance (Morri, 2020). For example, maps penetrated daily pandemic reports, providing data for making location-based decisions.

89 The pandemic also exposed the public to location-based services, such as the HaMagen¹
90 elective smartphone application that informed people in Israel if they had come into contact
91 with people who were later confirmed as positive for COVID-19 (National Cyber
92 Directorate, 2020). The data provided by this application were analyzed by cross-referencing
93 the location of patients' cellular devices with data gathered by the Israel Ministry of Health
94 about infected patients.

95 While the penetration of geographic representations in our lives during the pandemic is
96 undisputed, the degree to which people were able to make sense of what they were seeing is
97 unclear. More specifically, does geographic literacy shape how one makes informed
98 decisions? For example, could they explain spatial associations, patterns, and processes in the
99 COVID-19 context? Did they draw on geographic knowledge, critical spatial thinking, and
100 geographic perspective as a means for answering questions, resolving problems, and making
101 informed decisions?

102 ***Research Questions***

103 In striving to answer such questions, in this study we examined the manifestation of
104 geographic literacy among the public, with an emphasis on the use of maps within the
105 COVID-19 crisis context. Moreover, as geographic education may be key to promoting
106 geographic literacy, we also examined correlations between the participants' geographic
107 literacy, general education, and geographic education. The following two research questions
108 were presented: (RQ1) How is geographic literacy expressed in adults as seen through their
109 use of geospatial information in the context of COVID-19? (RQ2) Which variables regarding
110 education and attitudes are correlated with these expressions of geographic literacy?

¹ The app no longer exists for downloading from the app stores.

The findings of this study could offer empirical indications of the importance of geographic literacy, in the context of the COVID-19 pandemic, with implications for everyday life, and in relation to the teaching, learning, and evaluating of geography in formal settings. From a theoretical perspective, this study could also provide a synthesized definition for the term geographic literacy as a means for assessing people's geographic understanding regarding the specific geospatial phenomenon of the COVID-19 pandemic. The following sections provide a literature review of geographic literacy, map reading, and the COVID-19 pandemic, providing a solid foundation upon which to present the study and its findings.

LITERATURE REVIEW

What is Geographic Literacy?

The literature offers a range of academic and non-academic definitions for the term *geographic literacy*. In the past, geographic literacy was used to refer to abilities such as map reading, field observations, and place-location knowledge (Oigara, 2006); today, this term also encompasses *geographic thinking*, which is based on geographic knowledge, skills, and spatial thinking (Bednarz & Lee, 2019; Heffron, 2012). While some researchers include both *geographic knowledge* and *geographic competencies* in the term *geographic literacy*, others refer to the following subdivisions (Bar-Gal, 2003; Hughson & Wood, 2020; Moorman, 2019): *declarative knowledge*, which includes factual knowledge (e.g., defining the concept of *desertification*); *content knowledge*, that allows the understanding of processes (e.g., comprehending the concept of *desertification*); and *procedural knowledge*, which includes practical skills that are necessary for utilizing geographic tools (e.g., acquiring, organizing and analyzing geographic information, and describing geospatial patterns).

While reading a map and identifying a location serve as the foundation of geographic literacy, this term also includes problem-solving processes and critical and creative spatial thinking (Dikmenli, 2014). A critical spatial thinker is a person who understands problems,

derives solutions, and effectively communicates geographic processes, patterns, and outcomes (Bednarz & Lee, 2018; Sinton, 2017). Together, these enable the use of data and information to solve geographic problems and make decisions from a geospatial-geographic perspective, and as such, they serve as critical skills needed by a 21st-century citizen (Hintermann et al., 2020; Silviariza & Handoyo, 2021).

The interdisciplinary nature of geography, and its division into physical and human geography, have implications on the geospatial problems at hand, as well as the knowledge and skills needed to resolve them. Different fields of geography require different spatial thinking skills. For example, in physical geography it might be necessary to interpret rock units, while in social geography, it might be necessary to analyze spatial patterns and processes within the context of migration (McNeal & Petcovic, 2020). The current study addresses both physical and human traditions, with an emphasis on cartography and human interactions. The study also addresses how adults express their geographic literacy in the unique context of the COVID-19 pandemic and its related geospatial complexities.

In this study, we synthesize definitions presented by Edelson (2014), Kerski (2015) and Moorman (2019), addressing *geographic literacy* as the ability to use geospatial and geographic knowledge, skills, and reasoning – as a means for understanding and interpreting geospatial phenomena, their scope, distribution, and interactions. Specifically, we test the manifestation of geographic declarative knowledge, geographic skills, and geographic knowledge applications in decision-making processes.

Map Skills and Hazard Maps

An inseparable part of geographic literacy is map literacy, i.e., the ability to understand and use maps. This competency is impacted by a range of factors, such as map reading skills (e.g., recognizing symbol and directions (Xie, Reader, Vacher, et al., 2021), creating a “cognitive map” for reaching conclusions and making, e.g., orienteering decisions (Hegarty, 2011), and

applying previous knowledge within and outside the field of geography. Research mainly focuses on map-using skills, such as orienteering or navigating, rather than on developing map reading and comprehension skills (Arthurs et al., 2021). Understanding maps has been examined in the context of hazard maps, which are used to provide the public with information about dangers, such as floods or pandemics. These spatial-visual representations allow people to assess their own state of danger and take action to protect themselves. The purpose of these representations is to impact public opinion and attitudes while encouraging behaviors that mitigate social and personal risk (Haynes et al., 2007).

Many studies on hazard maps focus on the public's incorrect conclusions, in an attempt to develop more effective methods for presenting and conveying visual information (Lindell, 2020), with fewer studies examining the impact of visuality on people's understanding of disaster-related information (Liu et al., 2017). Cao et al. (2016) found that fire-spreading maps were more effective than text messages for understanding information, increasing risk perceptions and producing positive reactions. Yet, Casteel and Downing (2016) found no differences between different types of warning messages and understanding or decision making.

Effective transfer of information to the public through maps requires consideration of different types of geographic knowledge, including declarative and procedural knowledge (Zhou et al., 2016). While the main rationale of the studies presented above was to communicate information more effectively, this context may also be used to evaluate geographic literacy, as we do here in the context of the COVID-19 pandemic. For example, a study of people's understanding of information conveyed via interactive hazard maps indicated that better results were seen when using basic skills such as interpreting map symbols for determining quantities, compared to more advanced skills, such as using contour (MacPherson-Krutsky et al., 2020). This study also indicated that the objective measuring of spatial abilities

is more reliable than the self-reporting of these competencies; accordingly, we conducted such objective measuring in our study. Finally, some studies on risk literacy have directly addressed geoscience literacy and geospatial skill (e.g., Petty & Rule, 2008; Dupigny-Giroux et al., 2012). Raisa (2022) found that critical geospatial thinking in the context of flooding has an influence on student disaster preparedness, and Kamil (2020) perceives the mastering of geographic literacy as the ability to find solutions to natural disasters while reducing its adverse effects.

Understanding Geographical Information in the Context of the COVID-19 Pandemic

Since the outbreak of the COVID-19 pandemic, scientists, research organizations, and cartographers (professional and otherwise) have been creating COVID-19-related maps (Juergens, 2020). As in the case of risk maps, the public's understanding of the conveyed information is mainly studied from the map creator's perspective, in an attempt to identify effective map qualities. For example, Li (2021), shows that choropleth design yields higher accuracy of map understanding. A study by Thorpe et al. (2021) found no correlations between exposure to COVID-19 maps and public self-reports of knowledge, risk perceptions and intent to adhere to health regulations.

Since COVID-19 maps can highlight geospatial features in different scenarios, the findings of studies that examined their effectiveness can contribute to understanding the knowledge and skills needed to use the information, and to geographic education that promotes these abilities. We are inspired by research in science and math education, which uses real life scenarios to inform school practices. Critical assessment of newspaper graphs during the COVID-19 pandemic, for example, indicates a gap between the data literacy needed for understanding the media and what is taught in mathematical education (Kwon et al., 2021). The mathematical schemes that people hold impact the interpretation of data presented on diagrams and participants' estimations of the seriousness of the pandemic (Yoon, 2021). However, a stronger correlation was found between participants' mathematical identity

(attitudes towards learning math and seeing oneself as a ‘math person’) and their meaning-making of math in the news, compared to the roles played by mathematical education and mathematical literacy within the COVID-19 context (Heyd-Metzuyanim et al., 2021). While some studies on scientific and mathematical literacy indicate a positive correlation between education levels and the public’s knowledge, attitudes, and behavior regarding health-related guidelines (Hossain et al., 2021), others do not find a correlation between science education level and adherence to social distancing guidelines (Baram-Tsabari & Rozenblum, 2023). Accordingly, we concur that understanding information relating to the pandemic demands geographic literacy, which enables understanding, interpretation, and decision-making based on data and information that are graphically depicted on maps. One of the main sources for learning these skills is the education system.

Geographic Education and the Measurement of Geographic Literacy

Geographic education may promote geographic knowledge and skills, alongside people’s understanding of how to assess and use geospatial data and technological tools. In turn, this could enable people to resolve geographic issues and make educated decisions (Heffron, 2012). Striving to promote these competencies is expressed in a number of key geographic education documents that define geographic content and standards, such as *A road map for 21st century geography education* (Edelson et al., 2013). This outlook is in line with the Geo-Capabilities Approach, that perceives the acquisition of geographic knowledge as an enabler of geographic thinking and as encompassing the potential for promoting citizens’ competencies in the 21st century (Bustin et al., 2020). The Education Spatial Citizenship Approach perceives the “spatial citizen” as possessing the ability to cooperate and take part in spatial decision-making in relation to society, the economy, and the environment – using geo-media (Gryl & Jekel, 2018).

It is difficult to carry out a comparative analysis of geographic literacy due to the

different definitions and assessment methods used by different researchers (Lane & Bourke, 2019). Generally speaking, studies indicate low geographic literacy among different publics. For example, Dziauddin (2017), found a low level of geographic literacy among teenagers in Malaysia. Turner & Leydon (2012) and Solem et al. (2021) found low geographic knowledge and skills among students in Canada and the United States, respectively.

Evaluation studies in geographic education usually focus on declarative knowledge (i.e., factual knowledge of phenomena location) among school, college, and university students (e.g., Bijsterbosch et al., 2017). A large-scale international study conducted by the Gallup Organization in 1988 examined geographic literacy in adults from nine countries (Americans falter, 1988). Low geographic literacy scores were described, especially among participants from the United States. Similar indications of low geographic literacy were found in later large-scale international surveys (Roper Public Affairs, 2006). In addition, the geographic literacy of students in the United States was found to be relatively low and declining between 2014 and 2018 according to the National Assessment of Educational Progress (Solem et al., 2021). These studies emphasize the need for international assessment and standards regarding geographic education, as well as reaching a consensus regarding the cognitive dimensions and content to be assessed (Solem et al., 2018).

A range of educational factors have been found to impact geospatial thinking – and in turn, geographic literacy. These include specific pedagogies, such as Project-Based Learning, that promote geographic skills and knowledge and out-of-school learning via school trips (Putra et al., 2021; Wakabayashi, 2015; Xie, Zheng, Sun, et al., 2021). Makowsky & Martin (2021) found a significant and positive correspondence between geography achievement and attitudes, and how students perceive the value of geography for understanding the world.

Studies found correlations between students' level of interest in geography and their understanding of directions, as well as correlations between students' geographic education

and geospatial thinking (Verma, 2015; Wakabayashi, 2015). Geospatial knowledge, such as geospatial vocabulary and map-using competency, improves with age, education levels (Lee & Bednarz, 2012), and practice (McNeal & Petcovic, 2020). Spatial and mapping skills can be improved by instruction even in very young children (Petty & Rule, 2008).

In addition to formal geographic education, people can be exposed to geographic knowledge through informal educational settings, such as youth groups, field experiences, tours, non-academic tour guide courses, and enrichment courses for people who are passionate about geography (Noor et al., 2016). Based on the reviewed literature, the term geographic literacy was conceptualized, its components were determined and factors that might influence it were addressed.

METHODOLOGY

To assess expressions of geographic literacy among adults in Israel, with an emphasis on map use in relation to the COVID-19 pandemic (RQ1), a survey was conducted among a representative sample of the Hebrew-speaking adult population in Israel. This allowed for correlational research design to study educational and attitudinal variables, which correlate with the expressions of geographic literacy (RQ2).

A survey company recruited the sample in May 2020 by inviting participants from its internet panel, about three months after the pandemic outbreak in Israel. All participants provided informed consent and received monetary compensation. The study was approved by the Ethics Committee of the authors' affiliated educational institution (2020-052).

To ensure the representativeness of the research population, stratified random sampling was utilized, according to the following benchmarks: The sample included 456 Hebrew-speakers aged 18-70 (M 42.9; SD 15.7) from a representative online panel managed by

iPanel², the leading panel company in Israel with tens of thousands registered participants. As seen in Table 1, about half of the participants were male (48.7%), half had below-average income, and about one-third had average income (34%). About one-third of the sample held an academic degree (30.9%), 25.3% had a high school matriculation certificate, 20% graduated high school with 12 year diploma, 1.5% without high school education, and 7.7% of the participants held an academic degree in geography or a related topic (e.g., Middle East studies). In comparison, 34.4% of Israel's adult population (aged 24-65) holds an academic degree, 21.3% has a high school matriculation certificate, 28.4% has no high school matriculation certificate and 15% have no high school education (Biton & Yagur-Krol, 2020).

566 participants were excluded from the analysis according to the following criteria: (1) the time they took to answer the questionnaire was too short (less than four minutes), (2) many open-ended items were left unanswered, (3) the same value was provided for a series of items.

Research Tool: Measurements and Analysis

An online questionnaire "Geographic Literacy in the Context of COVID-19" (GLCC) was developed, with the following sections:

Geographic Literacy

This section included items that examined geographic declarative knowledge, geographic skills and geographic knowledge application (Hughson and Wood, 2020; Kerski, 2015; Moorman, 2019; Turner & Leydon, 2012). The items were adapted from items included in the Spatial Thinking Ability Test (STAT) developed by Lee & Bednarz (2012); the national geography test (Mashov) (National Authority for Measurement and Evaluation in Education,

² <https://www.ipanel.co.il/en/>

2016); international assessment tools, such as the Program for International Student Assessment (PISA) developed by the OECD (2018); and research tools that examine science and math literacy in the context of COVID-19 (Heyd-Metzuyanim et al., 2021; Taragin-Zeller et al., 2020; Dalyot, et al., 2022). All items addressed knowledge and skills that according to the national geography curriculum should be learned by 9th grade students.

Geographic declarative knowledge was assessed based on identifying the location of countries (Table 2, items 1-6) and additional factual knowledge (Table 2, item7).

Geographic skills refer to using geographic tools, which require practical knowledge that enables a certain activity to be performed. These items require understanding the meaning of the information extracted from the maps, including scale, directions, colors, symbology, description of geospatial phenomena and their connections (Table 2, items 8-28). The items included basic and advanced map related skills, which were classified and adjusted based on Xie, Zheng, Sun, et al. (2021) and the national geography curriculum. Some of the skill items used the context of COVID-19, while some items did not.

Geographic knowledge application that requires procedural knowledge and content knowledge was assessed based on respondents' ability to explain phenomena in terms of geospatial reasoning (Table 2, items 29-33). Some of these items were presented using a Hyphenate story-telling format relating to the COVID-19 pandemic that illustrates associations, in which participants could apply geographic knowledge, e.g., the need to advise elderly grandparents where to live by referring to the distribution of morbidity in Israel (Table 2, item 32).

Non-cognitive learning outcomes

This section of the questionnaire included assessments of three non-cognitive learning variables:

Sense of self-efficacy in geography that relates to people's perception of their ability to successfully complete geography-related tasks, such as using a map for a certain purpose (based on Bandura, 1997). The items were adopted from the national geography test (Mashov) (National Authority for Measurement and Evaluation in Education, 2016) (Table 3, items 1-9).

Attitudes towards geography that relates to emotional motivational aspects, such as how participants perceive the value, importance, and possible contribution of learning geography, how they perceive themselves as learners, and their interest in geography. In other words, this element relates to the degree to which adults feel that studying and knowing geography is important and helpful in understanding current issues. The items were adopted from the national geography test (Mashov) (National Authority for Measurement and Evaluation in Education, 2016) and from Kubiato et al. (2012). (Table 3, items 10-19).

Self-assessment of the need for additional geographic knowledge and map skills for understanding issues relating to the COVID-19 pandemic. This was achieved by referring to the need for basic map skills, such as understanding map symbols, and more advanced skills that require understanding the relationship between different representations on a map. These items were adopted from the national geography test (Mashov) (National Authority for Measurement and Evaluation in Education, 2016) (Table 3, items 10-19).

The participants were asked to rate their degree of agreement with each item in this section on a Likert-type scale of 1 (not at all) to 5 (very much so). Average scores were calculated for each non-cognitive outcome, after recoding reverse scoring of certain items as needed. About 100 of the 456 responders did not pass quality control in this section, and were not included in the analysis of these variables. We attribute this to problems with visualization issues, in which the 1-5 scale was not clearly presented on mobile phones, thus participants did not properly see all possible options they can choose from.

Socio-Demographic Data

The demographic variables included self-reporting of gender, age group, occupation, level of income (in relation to Israel's average income), level of formal education, highest formal instruction in geography, and the scope of geography studied in high school (Table 1).

Validation

Expert validation of the questionnaire involved three geography teachers, a lecturer in a pre-service program for geography teachers, and two researchers of science literacy in everyday life. These experts were specifically asked whether the knowledge items were related to the COVID-19 pandemic, and what geographic knowledge, skills, and geographic knowledge application are needed for answering each item correctly.

To establish face validity, we examined the wording and understanding of the items through interviews conducted with ten participants ages 20-60 while completing the questionnaire. Following this, certain items were altered. For example, where relevant, the names of the continents were added to certain maps.

Statistical Analysis

For each component of geographic literacy: geographic declarative knowledge, geographic skills and geographic knowledge application, a mean score of answers was calculated.

Since the research variables were measured on nominal or ordinal scales, we used non-parametric statistical analyses (Kim, 2014). The Friedman test was used to examine differences between the distributions of the geographic literacy components. For post-hoc comparisons, we used the Wilcoxon tests with Bonferroni corrections for multiple comparisons (Gibbons, 1993). To study differences in geographic literacy scores between groups, the one-way analysis of variance (ANOVA) was conducted. The Kruskal-Wallis non-

parametric test was used to compare geographic literacy between median scores of the levels of education. Spearman's correlation coefficient examined relationships between geographic literacy and non-cognitive outcomes. Z-tests were conducted to compare correlation strengths (Soper, 2022).

RESULTS

Expressions of Geographic Literacy among Adults in the Context of COVID-19

The findings indicate a relatively low geographic literacy level among the 456 participants (Mean 56.0 ± 22.9 on a scale of 1-100). Table 2 details the item scores (listed below) in each of the geographic literacy components alongside the average scores of geographic literacy and its three components.

Participants' achievements in declarative knowledge were the highest among the three components [65.7 ± 34.4], but presented wide variance between participants and between items. For example, four out of five participants knew how to locate the United States on the map (81.1%, Table 2, item 1), more than those who succeeded to locate Israel – their own country (72.6%, item 3).

Geographic skills were harder for participants [57.6 ± 22.0]. The participants achieved the highest scores for items that required basic map skills [67.6 ± 26.4] compared to advanced map skills [50.1 ± 19.7]. For instance, about three-quarters of the participants understood the purpose of a symbol presented on the map (74.8%, item 15), while only about half of the participants correctly interpreted symbols that show changes over time (51.1%, item 25) – this was a True/False question, therefore no better than a guess. Interestingly, the success in an item referring to interpreting a symbol on the map of Israel (item 11) was much higher (75.9%) than a similar item that had an international context (34%, item 27).

The lowest level of achievement was demonstrated in geographic knowledge application [44.5 ± 27.0]. The highest score in this component (74.6%, item 29) was achieved for an item

that required an understanding of the information type needed to be added to the map that is critical to better understand the pandemic severity in different countries. The lowest score in this component (40.1, item 33) required an understanding of the reason for the low number of confirmed cases in Africa.

Educational Variables and Expressions of Geographic Literacy

Three ordinal variables were examined to assess the second research question: level of formal education, scope of geography studies in high school, and the highest formal instruction in geography (Table 1). Their correlation was examined with the average score of geographic literacy, encompassing all three components.

A significant correlation was found only between education level and geographic literacy with a positive medium-weak correlation [$r_{s(456)}=0.28$, $p\leq.001$]: geographic literacy differed between the three education levels [$H_{(2)}=35.54$, $p<0.001$]. Indeed, the one-way ANOVA resulted in significant differences [$F_{(2,453)} = 17.93$, $p < .001$], with the highest results being seen among participants with an academic degree [63.1 ± 20.3], followed by participants who graduated from high school with a matriculation exams certificate or who had completed non-degree higher education studies [56.1 ± 22.3]. The lowest levels of geographic literacy were found among participants who only completed junior high or high school without a matriculation exams certificate [46.10 ± 23.70].

No significant correlations were found between highest formal instruction in geography [$r_{s(438)}=0.07$, $p=0.130$] and geographic literacy, nor between geographic education level [$r_{s(456)}=0.04$, $p=0.442$] and geographic literacy. The highest geographic literacy level was found for respondents who studied geography in informal settings, such as professional non-academic courses [63.5 ± 19.2], which was even higher than for those who studied geography in a formal academic setting [60.8 ± 21.7].

Non-Cognitive Learning Outcomes and Expressions of Geographic Literacy

Self-efficacy in geography and attitudes towards geography were above average on a scale of 1-5 (Table 3, 3.7 ± 0.9 and 3.6 ± 0.8 , respectively). Respondents perceived a relatively low need for additional geographic knowledge and map skills for understanding issues relating to the COVID-19 pandemic (2.1 ± 0.9).

Strong-moderate positive correlations were found between self-efficacy in geography [$r_{s(373)}=0.57$, $p<0.001$] and geographic literacy. Similarly, attitudes towards geography were significantly correlated with geographic literacy [$r_{s(373)}=0.48$, $p \leq 0.001$]. A significant negative correlation was found between the need for additional geographic knowledge and between geographic literacy [$r_{s(363)}=-0.32$, $p \leq 0.001$]. In other words, adults with a sense of self-efficacy in geography and positive attitudes towards geography, and who expressed less need for additional geographic knowledge, had higher geographic literacy.

It is important to point that while the non-cognitive outcomes were strongly correlated with expressions of geographic literacy in the context of COVID-19, the highest formal instruction in geography and geographic education were not. Following these findings, we further examined correlations between the educational variables and attitudes towards geography and self-efficacy in geography.

Low yet positive correlations [$r_{s(373)}=0.18$, $p \leq 0.001$] were found between attitudes towards geography and the educational variables: level of education, the highest formal instruction in geography, and level of geographic education.

A significant strong correlation was found between sense of self-efficacy in geography and attitudes towards geography [$r_{s(363)}=0.65$, $p \leq 0.001$]. A significant positive correlation was found between education level [$r_{s(373)}=0.26$, $p<0.001$] and sense of self-efficacy in geography, and between the highest level of geography studies [$r_{s(361)}=0.125$, $p<0.001$] and a sense of

self-efficacy in geography.

Older people were slightly more positive towards geography [$r_{s(373)}=0.22$, $p\leq 0.001$]. Less positive attitudes towards geography were seen among the youngest participants (aged 18-22) [$N=58$, 3.3 ± 0.8], while the most positive – albeit still moderate – attitudes were found among the older participants (aged 50-70) [$N=155$, 3.8 ± 0.7]. Finally, younger participants tended to report having a greater need for additional geographic knowledge and map skills for understanding issues relating to the COVID-19 pandemic [$r_{s(363)}=-0.17$, $p<0.001$].

DISCUSSION

Manifestations of Geographic Literacy in the Context of COVID-19

In this study, we explored geographic literacy among adults in Israel within the context of the COVID-19 pandemic. Our findings indicate low *geographic literacy*: the average percent of correct answers (56.1%) that assessed knowledge and skills that participants have acquired at school on the 9th grade (as per the national curriculum). Higher achievements were seen in geographic declarative knowledge and in geographic skills (65.7 % and 57.6%, respectively) than in the application of geographic knowledge scale (44.5%). Indeed, the latter (Table 2, items 29-33) require disciplinary content knowledge and procedural knowledge, based on geospatial critical thinking combined with a geographic perspective. Such knowledge allows the understanding of geospatial phenomena, their causes, and their geospatial patterns (Desouza, 2021; Kerski, 2015; Stoltman et al., 2017).

While the specific items used to assess the components of geographic literacy in our study might have an impact on our results, our findings in general are in line with previous studies. For example, a study involving 16-year-old Malaysians indicates low overall geographic literacy, i.e., measured knowledge and skills (Dziauddin, 2017). In our study, participants achieved higher scores for items requiring basic map skills (67.9%) compared to advanced

skills (50.5%), similar to the findings of an earlier study in the context of a natural hazard maps (MacPherson-Krutsky et al., 2020). These similarities lend validity to our findings.

Recognition of the importance of geographic teaching can be seen in the Geography for Life Report, by the US National Council for Geographic Education, that presents geographic standards for different age groups (Bednarz, 1994; Heffron, 2012). In Israel, the school geography study program is spiral, with specific issues and skills being revisited at an older age in greater depth. The program also provides greater geospatial context as students age. The younger children first learn about their neighborhood, and next about their city and country; only later do they progress to learn about the global level. The study program is based on repetition, expansion, and enrichment of physical and human geographic knowledge geographic skills.

Based on the national curriculum, adults who graduated from the Israeli school system would be expected to answer the questions presented in this study to a higher degree. The low levels of geographic literacy exhibited by the participants in this study could have stemmed from a lack of repetition of the practical and theoretical geographic learning, or alternatively from an insufficient number of geography lessons at school (a known phenomenon in Israel).

The COVID-19 pandemic was anchored within both global and local contexts, thereby requiring the public to interpret maps at different scales (i.e., world, state, town, or neighborhood), while making cognitive connections between local and global phenomena. The impact of the given context could play a role in creating new knowledge which is based on previous experience and connections to present situations (Johnson, 2002). Indeed, many factors impact map literacy and geospatial thinking (Wakabayashi, 2015; Pollack, 2012). Xie, Zheng, Sun, et al. (2021) found that geospatial thinking is impacted by previous geographic knowledge, knowledge in additional fields, and a geographic learning interest. In our study, the ability to correctly answer items about the meaning of the symbol size and distribution,

for example, could be related to linguistic ability (among other reasons) – i.e., inferring meaning from the map’s title; or to quantitative literacy – i.e., understanding the concepts of density, distribution, and scale. Future studies could examine geographic literacy as part of an assembly of literacies, and in relation to the contextual teaching and learning approach to further contribute to holistic understanding (Johnson, 2002).

An example for the interplay between geographic skill and the specific context of COVID-19 can be seen in the questions concerning the world map of COVID-19 spread. The map depicts certain areas in red, such that almost all of Europe is depicted in red. In the study, 56.4% of the participants understood that this is related to semiotics, i.e., that the markings that symbolize COVID-19 confirmed cases overlap with one another, thereby creating a “red zone” (table 2, item 23). This challenge could be related to participants’ difficulty in understanding the connection between zooming in, scales, and visual changes on the map, which related to quantitative literacy as well (e.g. Table 2, item 28, 27% correct). Previous studies on this issue have indicated that learning through practice affects the understanding of geographic scales (Zhao et al., 2020). Moreover, understanding the geospatial patterns shown on the map in this question requires geospatial thinking accompanied by critical thinking that will allow one to examine and evaluate alternative hypotheses (Hintermann et al., 2020). Advanced map skill items require critical geospatial thinking to understand spatial information, describe spatial patterns and understand spatial processes and outcomes (Moorman, 2019; Sinton, 2017). Therefore, these skills are considered higher-order thinking skills (Utomo, 2019).

Struggling with map representations may have impacted publics’ ability to correctly infer data presented by the media in relation to COVID-19. This includes for example, locations of confirmed patients for taking personal protection measures, or more generally, understanding the pandemic’s extent. This impacts both on the individual level and societal level. In other

526 words, low geographic literacy could hinder one from making informed decisions and
527 optimally addressing 21st century challenges.

528 **Does geography education promote geographic literacy?**

529 One of the surprising findings of this study was that participants' level of general education
530 had a stronger correlation with geographic literacy than how much geography one learned.
531 One possible explanation is that other literacies, rather than geography, explain the
532 difference. But findings might be better understood within the context of the Israeli education
533 system, whereby geography is only mandatory up to the 9th grade, after which geography is
534 optional as a major (Ministry of Education, 2015). Over the past few decades, the geographic
535 study program has undergone changes in content, pedagogical values, and the integration of
536 learning through Geographic Information Systems. Moreover, within high school and
537 academic education, additional disciplines may develop geographic literacy, such as Middle
538 East studies, tourism, environmental studies - and more.

539 Interestingly, participants who acquired instruction in geography via professional courses
540 (e.g., tour guide) exhibited higher geographic literacy than those who had studied geography
541 in a formal academic framework. A possible explanation might have to do with the pedagogy
542 employed in the courses, that provides more experiential learning and less abstract teaching.
543 Studies indicate an interaction between experiential-based learning and developing geospatial
544 competencies (Flynn, 2018; Hedley et al., 2013). In addition, not all participants who studied
545 geography in a formal setting may have done so by choice, but perhaps as a mandatory
546 course within a university degree.

547 An important outcome of this investigation is the finding that participants' self-efficacy
548 and attitudes towards geography had a stronger correlation with geographic literacy than the
549 educational variables – either geography education or general education. Non-cognitive

outcomes such as self-efficacy and attitudes towards geography could hinder or enhance people's ability to interpret information on maps and apply geographic knowledge in response to day-to-day challenges. This finding echoes Heyd-Metzuyanim et al. (2021), who found that mathematical identity and attitudes towards mathematics were more strongly correlated – rather than mathematical education - with the ability to understand COVID-19 related information on the media.

Older participants in our study held more positive attitudes towards geography, and required less geographic knowledge and skills for understanding maps in relation to the pandemic. One explanation might be their richer life experiences and informal geographic education. Alternatively, this may stem from younger participants' greater dependence on smartphones, which may have decreased their experience with relevant skills (Sunday et al., 2021). Finally, our study is part of a series of efforts to use the pandemic as an opportunity for studying the transfer of school content and skills into real world scenarios, from science education (Taragin-Zeller et al., 2020), and data literacy (Tabak & Dubovi, 2023), to math education (Bloom et al., 2020; Heyd-Metzuyanim et al., 2021) and geoscience (Lindell, 2020). This may more generally contribute to our understanding of the role of schooling in adult life.

Limitations

When interpreting the results of this study, several limitations should be addressed. First, relatively few studies have examined adult geographic literacy, making it harder to generalize the findings across national and educational contexts. Moreover, as different studies assess geographic literacy using different variables and measurements, comparisons between studies are rather complex. Furthermore, geography includes both physical and human subfields, that may have different perspectives on the most salient content and skills needed, and how to apply them. In this

sense the specific context of COVID-19 might have created a unique opportunity, but also unique circumstances, that called for certain knowledge and skills, while disregarding others. While we focus on geographic literacy in our analysis it is obvious to us that answering the questionnaire correctly calls for additional literacies that stem from disciplines other than geography. Therefore, it is difficult to isolate the sole contribution of geographic education to the participants' geographic literacy. Another limitation is the wide range of age groups involved in the study, that might have studied different geographic curricula. From a technical point-of-view, as the survey was conducted online, some participants may have used smartphones and did not have optimal visualization conditions for answering the Likert-type items. Moreover, to avoid technical problems, only static maps were used, such that future studies might also examine geographic literacy in the authentic context of dynamic maps that represent spatio-temporal processes. Interactive maps could be embedded in questionnaires, documenting participant's interactions with the map, thus achieving a more detailed understanding related to geographic literacy and geospatial thinking.

Implications and Conclusions

Geography education plays a key role in developing knowledge and skills that are needed for day-to-day challenges. These were intensified during the COVID-19 pandemic, when data was often conveyed via maps, and when phenomena and processes comprise geospatial expression and explanations. This study was based on the perspective whereby the pandemic provided an opportunity for examining knowledge that was acquired through geographic education prior to and regardless of the pandemic, but that needed to be applied specifically within the pandemic context.

The findings of this study indicate low geographic literacy among adults in Israel, expressed as difficulties in understanding the geospatial context of COVID-19. This is

manifested by difficulty in interpreting, understanding, and applying information appearing on maps, showing little understanding of geospatial patterns and processes. We also learned that positive attitudes towards geography go hand in hand with the enhanced ability to interpret data on maps while dealing with geospatial questions. A conclusion that has implications for geographic education is that geographic literacy must be promoted in a range of formal and informal educational frameworks, while caring for improving people's attitudes towards geography.

Our findings highlight a number of pedagogical insights, which have practical implications for geographic educators: the need to broaden students' geographic knowledge and skills, through repetition and expansion over time; emphasizing a geographic perspective in the study of day-to-day challenges in geography classes; and offering learning that acknowledges the interdisciplinarity and multidisciplinary, of knowledge in the context of practical experience. The importance of related literacies should also be acknowledged within geography, such as data, digital-technological, visual, quantitative, linguistic, environmental, and health literacy.

Geographic data should be made accessible to the public, while considering users' geographic literacy and geospatial thinking aptitudes. The call for geographic education relates to all stakeholders - including teachers, instructors, teacher mentors, curricula and learning material developers, policy makers, and educational researchers. The aim should be enhancing geographic literacy, geospatial thinking and critical thinking to meet the needs of citizens. Geography, geospatial thinking and geographic literacy should become an integral part of the vocabulary of educational discourse.

Disclosure Statement

The authors declare no competing interests.

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Table 1. Demographic characteristics of the sample participants (N=456)

Table 2. Geographic literacy components and related items in descending order of percentage of correct answers

Table 3. Non-cognitive learning outcomes, relevant items, and mean results on a 1-5 Likert scale

Table 1. Demographic characteristics of the sample participants (N=456).

Characteristic	%
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Gender	Male	48.7
	Female	51.3
Age group	18-22	15.1
	23-29	14.3
	30-39	14.0
	40-49	17.3
	50-70	39.3
Field of occupation	Administration, marketing, white collar	37.9
	Academic, hi-tech	18.6
	Education and training	14.0
	Nursing and medicine	6.1
	Physical or technical work	8.6
	Art, design	2.6
	(No answer)	(12.2)
Income	Below average	50.0
	About average	34.0
	Above average	16.0
Education		
Level of education	Elementary / junior high	1.5
	High school without matriculation exam certificate	21.7
	High school with matriculation exam certificate	25.3
	Higher education without degree	20.0
	Academic degree	30.9
Highest level of geography studies at school	Did not study geography in high school	41.8
	Studied geography in high school but did not take elective geography	38.0
	Took the 3-point geography high school matriculation exam (i.e., minor)	13.6
	Took the 5-point geography high school matriculation exam (i.e., major)	6.6
Highest formal instruction in geography	Elementary / junior high school	39.0
	High school	48.0
	Academic degree in geography or a related field (e.g., Israel studies, Middle East studies)	7.7
	Professional course (e.g., tour guide)	5.3

Table 2. Geographic literacy components and related items in descending order of percentage of correct answers.

In parenthesis: type of question (true/false, yes/no, in multiple choice questions the number

910 indicates the number of options). For the geographic skills component, we added: basic or
 911 advanced map skills (marked: basic/advanced). The percentage of respondents that answered
 912 correctly is calculated out of all respondents (“no answer” was treated as a wrong answer).
 913

Declarative Knowledge		65.7 (SD±34.4)* normalized relative to the maximum possible score
Component / Item		% Correct Answers (n=435)
1	Location of the United States on the world map (One of six options)	81.1
2	Location of Spain on the map (One of six options)	75.9
3	Location of Israel on the map (One of six options)	72.6
4	Location of China on the map (One of six options)	70.4
5	Location of India on the map (One of six options)	65.4
6	Location of Russia on the map (One of six options)	65.1
7	What is the correct definition of “geography”? (One of four options)	28.5
Geographic Skills		57.6 (SD± 22.0)* normalized relative to the maximum possible score
Component / Item		% Correct Answers (n=435)
8	On the “Exposure to COVID-19” map of Israel, could there be more than one marking for the same patient? (yes/no, advanced skills)	80.3
9	On the global map, the entire area of Europe is marked in red because there are confirmed COVID-19 cases everywhere in Europe (true/false, advanced skills)	78.7
10	On the global map, in African countries the symbols are smaller than in European countries because there are fewer confirmed patients (true/false, basic skills)	76.1
11	On the “Exposure to COVID-19” map of Israel, if there are many blue circle symbols in a certain town, what does this mean? (One of four options, basic skills)	75.9
12	What can you learn from the “Exposure to COVID-19” map of Israel? (One of four options, basic skills)	75.9
13	On the global map, on Jan 13, 2020, there were confirmed cases of the virus in China (true/false, basic skills)	75.7
14	On the global map, in African countries, the circle symbols are smaller than in European countries because not many humans lives there (true/false, basic skills)	75.0
15	On the global map, the size of the circle symbols on the	74.8

	map expresses the number of confirmed COVID-19 cases in that country (true/false , basic skills)	
16	On the global map, the United States is located to the west of Europe (true/false , basic skills)	72.1
17	On the global map, over time the number of new confirmed patients decreased in China and increased in the United States (true/false , advanced skills)	71.7
18	On the global map, over time the number of confirmed patients decreased in China (true/false , advanced skills)	69.3
19	Which of the following is a possible explanation for your answer to the previous question (" <i>What can you learn from the exposure to COVID-19 map?</i> ", item 13) (One of four options, basic skills)	68.6
20	On the global map, in the southern hemisphere, the number of confirmed COVID-19 cases is larger than in the northern hemisphere (true/false , basic skills)	67.8
21	On the global map, on April 22, 2022, in China there were cases of COVID-19 infected patients (true/false , basic skills)	65.1
22	According to the map and the walking instructions, which of the following buildings is nearest to you? (One of six options, advanced skills)	57.9
23	On the global map, the red color covers almost the entire area of Europe because there are many countries in Europe and the circles overlap with one another (true/false , advanced skills)	56.4
24	On the global map, some cases presented in a "yellow circle" could become a "light blue circle" over time (<i>the colors symbolized the existence and number of new positive patients</i>)(true/false , advanced skills)	53.0
25	On the global map, on April 22, 2022, in China there were new cases of COVID-19 infected patients (true/false , basic skills)	51.1
26	While calculating the distance between your home and a marked location, you checked the map and saw that the scale of the map is 1:100,000. What does this mean? (Two of four options, advanced skill)	39.8**
27	On the global map, a circle symbol on the map indicates places where confirmed patients visited and may have spread the infection (true/false , basic skills)	34.0
28	You are watching a dynamic digital map on your smartphone. You zoom in and can now see more details on the map. Has the scale of the map changed, and if so, how? (One of four options, advanced skills)	27.0
Geographic Knowledge Application		44.5 (SD± 27.0)* normalized relative to the maximum possible score
Component / Item		% Correct Answers (n=435)
29	On the global map, which information do you think is important to add so that people can know more about the severity of the pandemic in different countries? (One of	74.6

	four options)	
30	An article published by The Guardian Newspaper on April 11, 2020, stated that “People in India say that they can see the Himalaya for the first time in decades.” What could be the reason for this? (One of four options)	65.1
31	“You have been asked to add information to the map that explains how the virus spread from place to place around the world. What information would you add to the map”? (One of four options)	58.3
32	“Your grandparents live in a town with a relatively large number of confirmed patients, so they have decided to move to a different area... where there is a much smaller chance of their contracting the virus... Look at the “Exposure to COVID-19” map and choose at least two areas that you would recommend they move to during the pandemic” (five of seven options)	42.2**
33	What do you think is the reason for the low number of confirmed cases in Africa? (three of six options)	40.1**
Geographic Literacy		56.1 (SD±22.9)* normalized relative to the maximum possible score

* Declarative Knowledge, Geographic Skills, and Geographic Knowledge Application are normalized relative to the maximum possible score in each component, since some items received more than one point each (these are not averages of the items).

** The average values for items that had more than one answer were weighted to include partial answers.

921 **Table 3.** Non-cognitive learning outcomes, relevant items, and mean results on a 1-5 Likert
922 scale.
923

Non-cognitive learning outcome			M	SD
Sense of self-efficacy in geography			3.7	0.9
Sense of self-efficacy in geography as expressed through self-valuations of geographic abilities	1	I know how to plan a route using a navigation app	4.1	1.1
	2	I know how to use google maps	4.0	1.1
	3	I know how to find a location using a dynamic digital map (such as google maps)	3.9	1.1
	4	I know how to find using a dynamic digital map (such as google maps) the legend (explanation of colors and signs)	3.7	1.1
	5	I know how to find a location on a paper map (static map)	3.7	1.1
	6	I can understand and draw conclusions from graphs and maps presented in newspapers	3.6	1.1
	7	I can read graphs and maps displayed in newspapers	3.5	1.2
	8	I know how to use GoogleEarth	3.5	1.3
	9	I know how to plan a route using a paper map to get to a new place	3.5	1.3
Attitudes towards Geography*			3.6	0.8
Attitudes towards geography and oneself as a geography learner as expressed through motivational-emotional aspects	10	Geography is essential for understanding the world around us	3.9	1.0
	11	Geography interests me	3.2	1.1
	12	I'm good at geography	3.2	1.0
	13	I love geography	3.1	1.1
	14	I am familiar with geographical phenomena	3.1	1.0
	15	Geography is not my strong point	2.5	1.2
	16	Geography is a boring subject	2.3	1.2
	17	Geography was my hated subject in school	2.1	1.2
	18	There are basic things about geography that I've never been able to learn (e.g., finding directions on a map, understanding the legend and signs on a map)	2.0	1.0
	19	Geography is a profession that has nothing to do with real life	1.7	0.9
A need for additional geographic knowledge to understand representations during COVID-19			2.1	0.9

pandemic				
Rate to what extent you feel you need more geographical knowledge:				
Self-assessment of the need for additional geographic knowledge and map-skills for understanding issues relating to the COVID-19 pandemic (meta-cognition)	20	How to check if the data is correct	2.7	1.3
	21	How to compare maps	2.4	1.2
	22	How to check the source and who created the map	2.4	1.2
	23	How to understand the relationship between different data on a map	2.3	1.2
	24	How to draw conclusions from data on maps	2.3	1.2
	25	How to draw conclusions from data on maps	2.2	1.2
	26	Knowledge of the meaning of symbols and colors on the map	2.2	1.1
	27	Knowledge of scale in maps	2.1	1.2
	28	Location of countries	2.0	1.2
	29	Knowledge of directions on the map	1.9	1.2
	30	Knowledge of country names	1.7	1.0
	31	Location of continents	1.7	1.1
	32	Knowledge of names of the continents	1.6	1.0

* The scales of the negative statement were reversed before calculating the average.