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Form Follows Feedback: Rethinking Cartographic Communication

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Communication was the first paradigm to gain widespread acceptance amongst the international cartographic community. Drawing on aspects of information theory to rationalise the process of transferring knowledge from the map-maker to the map-user, its aim was to optimise 'map effectiveness' by treating the map as a vehicle for communication. From the emergence of the first map communication models of the late 1960s until their demise by the early 1980s, arguably no paradigm has since unified the goals of cartographic theory and practice as successfully. This paper offers a fresh critical appraisal of the cartographic communication paradigm and re-examines its relevance at a time when social media are widely used for disseminating maps and generating feedback – a crucial element of any communication system that received limited attention in earlier map communication models. By proposing a new map communication model, the paper calls for greater convergence between cartographic theory and practice, together with new insights for educating future map-makers.

Introduction

We have used maps for communicating our place in the world long before the development of written language (see, for example, Utrilla et al., 2009). Cartography, which may be defined as the art, science and technology of making maps (Kent and Vujakovic, 2017), gives meaning to spatial relationships and turns space into place. The emergence of theories of cartographic communication after the Second World War, a conflict which had seen the proliferation of propaganda mapping and the erosion of trust in cartography, aimed to rationalize the process of map creation and to establish cartography as a scientific discipline. In order to succeed under the post-war hegemony of modernism, cartography would therefore come to rely on the values of scientific inquiry, such as objectivity and empirical research, to provide its authority, purpose, and direction. In particular, cartography was redefined as a communication science 'as distinct from a rather unwieldy art-science relationship, regarded by many as an uncomfortable operating zone' (Sorrell, 1978: 31). The paradigm saw the introduction of successive map communication models during the 1960s and 1970s (e.g. Moles, 1964; Board,

1967; Koláčný, 1969; Ratajski, 1971; Balasubramanyan, 1971; Petchenik, 1974; Robinson and Petchenik, 1975; Robinson and Petchenik, 1976; Board, 1977; Petchenik, 1977), which, in their simplest form, portrayed maps as 'channels' that transmitted information from a source (the world) to a recipient (map reader) (Montello, 2002: 290).

While their focus was on reaching a single, optimal map solution, a combination of their increasing complexity with a lack of agreement about the nature of their fundamental elements led to the demise of the cartographic communication models by the early 1980s. More fundamentally, as selective representations, the nature of maps means that they are never only about technology or design (Kent and Vujakovic, 2017) and the cartographic communication paradigm was supplanted by the 'epistemological shift' of critical cartography (e.g. Harley, 1989, 1990). This presented the idea that maps – like other texts – are not (and cannot be) value-free or neutral (Perkins, 2017: 80). Developments in technology subsequently transformed the way maps were made, used and shared. The dominant cartographic medium moved from paper to digital and the availability of new mapping tools (such as geographic information systems, vector graphics software, web map servers, application programming interfaces and the availability of consumer-grade global navigation satellite system receivers) gave rise to the user-cartographer and led to the so-called 'democratisation' of mapping in the new millennium.

With the multitude of cartographies available and the ability to issue and re-issue maps in an instant, some have claimed that the search for the optimum map is over (Crampton, 2001: 236–237). Others have expressed concern that good design (and hence the acquisition of cartographic skills, judgement and professional identity) is disappearing in an age of web mapping because there is a diminishing return on the time spent on their aesthetics, since the medium is designed to be ephemeral (Muehlenhaus, 2014: 31). Indeed, maps are being treated and consumed as pictures, whose 'entire purpose is to provide quick visual delight and nothing more' (Field, 2014: 2).

Despite attempts to build on the cartographic communication paradigm through an enhanced understanding of geovisualization, for example as a process from exploring unknowns to revealing knowns (MacEachren, 1995), the development of a broad theoretical framework with the clear goal of improving map design (at least with the international traction of the map communication models) has proved to be elusive. More importantly, the sustained lack of debate concerning the development of new theoretical frameworks in this applied discipline has widened the gulf between theory and practice. Professional cartographers struggle to make their maps relevant (Norwood and Cumming, 2012), while amateur map-makers are creating and disseminating curiosity-driven maps via social media that are liked and shared by tens of thousands. There is a need for a theoretical framework to support the creation and design of maps that better serve the needs of society.

Arthur Robinson's *The Look of Maps* (1952) put forth the proposition that the function of maps is to communicate to people (Montello, 2002: 285) and appraisals of the legacy of the communication paradigm (e.g. Montello, 2002; Board, 2017) acknowledge its achievement both as an established framework for analysing how maps work and as a lens for seeing cartography as a science. The paradigm endures in current cartographic textbooks (e.g. Brewer, 2016; Darkes and Spence, 2017), principally as a way of explaining that cartography is essentially about communicating a message via a map. Chilton and Kent (2017) found that communication also appears to be an implicit goal amongst so-called 'neo-cartographers', i.e. map-makers with no formal cartographic training.

Nevertheless, the map communication models were devised at a time when the dominant medium for maps was paper (and, hence, static), when the majority of published maps were issued by organizations, and when scope for receiving feedback from users was much more

limited. Indeed, the models tended to regard the flow of information transfer as a linear and unidirectional process, disregarding the possibility for feedback and omitting a critical step towards improving the effectiveness of communication. But Robinson's (1952) post-war proposition was also based on the idea that by optimising its design, users are more willing to trust a map. This implies that the map's function of communication depends on its visual appearance, which, in turn, depends on explicit and implicit design decisions made by map-makers (Montello, 2002: 285). Aesthetics therefore plays a key, if neglected, role in cartographic theory (Kent, 2005).

Although the processes of mapping and the making, sharing and use of maps has changed dramatically since the map communication models were first devised over fifty years ago, people still place their trust in maps and map-makers still possess the capacity to intentionally mislead (Monmonier, 1991). It is also possible to draw some similarities between the cartographic anxieties of the post-war world (with regard to the dangers of state-driven propaganda mapping) and those of the new millennium (the dangers of user-cartographers disseminating misleading information via maps). Both concern small-scale thematic maps and propaganda mapping is alive and well today, as demonstrated ahead of the UK's 2016 referendum on leaving the European Union (Kent, 2016). Furthermore, Robinson (in press) suggests that it is not implausible to imagine an intentional disinformation campaign that couples viral social media with the power of maps.

In contrast with 1960s and 1970s, mass feedback can now be generated (however articulate and accurate) and received via social media, and maps can be subsequently edited, refined and re-issued in a fraction of the effort, time and cost. Rather than being finished, fixed and stable representations, digital maps are displayed in a multitude of formats and are constantly in flux. If the pursuit of optimal design solutions remains, there are now significant opportunities for user-focused cartographers to explore the use of feedback as a means for improving map design, which, according to Montello (2002: 298) should be considered in terms of its effectiveness for helping people to understand the world.

This paper revisits the cartographic communication paradigm and critically examines how it may be potentially updated and developed as a theoretical framework for practising cartographers today. It explains the development of the early map communication models and discusses their limitations before considering how new map-making technologies and feedback from social media may provide the basis for proposing a new map communication model. Further avenues for research are suggested, with the aim of assisting cartographers in creating maps that are more effective, relevant, and trustworthy.

Origins of the cartographic communication paradigm

Although attempts were made to establish cartography as a scientific discipline before the Second World War, most notably by Max Eckert (1868–1938) (Papay, 2017), they lacked a sound basis in empirical research, even if maps themselves enjoyed a high level of credibility. For example, Jervis (1936: 152) had remarked 'Such is the high standing of the cartographers' art that anything put on a map now bears the stamp of authenticity and genuineness; we trust a map'. However, the wide dissemination of propaganda maps – particularly in the cartography of Haushofer and the German *Geopolitik* school – had to a degree betrayed that trust. The ensuing intention was thus to place the cartographic profession on a trajectory where it could be assured of evolving into a serious scientific discipline. Arthur Robinson (1915–2004), who had overseen the creation of thousands of maps as Head of the Map Division of the US Office for Strategic Services from 1942 to 1945, outlined his vision for cartography in *The Look of Maps* (1952), noting Speier's (1941) observation that the onset of explicit propaganda mapping was early recognition that visual relationships in maps mattered (Montello,

2002: 287). Robinson published *Elements of Cartography* a year later, the first edition of the principal textbook of Western cartographic practice of the twentieth century. Recognizing the conditions were favourable in realising his vision, he stated 'The profession is [...] on some-what sounder ground now for it has a more universal appeal. Several factors have combined to promote this phenomenal growth. One of the most important is the fact that two world wars have occurred' (Robinson, 1953: 6).

Indeed, with the intensive utilization of maps during the world wars and with new methods of survey and colour printing in photogrammetry and photolithography, cartography could address ever-increasing demands and acquire a more prominent role in a modern society. Theoretically, this involved improving the efficiency of information transfer by isolating the purpose of a map to its message, and practically, reducing 'noise' (Robinson and Petchenik, 1976) by controlling variables such as poor symbol design. The goal was to arrive at a single, optimal cartographic solution that would function within known parameters of use.

The most unpredictable, and yet perhaps the most important, element of cartography is the user of a map and the first theories of cartographic communication sought to under-stand and control the factors affecting map use. Previously, the user had not occupied such a significant role; the one and only condition a map had to fulfil was to be accurate and reli-able from a geometrical point of view (Koeman, 1971: 169). But, as Crampton (2001: 237) asserts, the new research agenda to improve map design was based on user-testing, and as Robinson, Morrison and Muehrcke (1977: 6) noted, 'perhaps nothing to date has opened up more research topics than the increased concern for the map user'. In a climate of scientific positivism, this implied the quest to determine universal principles that would assist the car-tographer in the creation of the optimum map to serve defined parameters of use.

The application of general theories of information transfer, such as those of Hartley (1928), with a view to improving map design began to gain momentum and by the late 1960s, vari-ous theories of cartographic communication had emerged. As Gordon (1997: 85) states, the advent of a theory of information was an exciting one as it offered the possibility of quantify-ing information capacities in systems as diverse as television channels and neurons. At the time, Board (1967: 673) claimed 'it is a truism to assert that maps are vehicles for the flow of information' and Koeman (1971: 170), in using the definition that maps are 'vehicles' in the process of communication by means of graphic symbols, believed that most of the problems regarding the truth, accuracy and function of maps could be solved by the consistent applica-tion of universal principles. By identifying and examining the elements involved in the gamut of the cartographic process independently, these theories sought improvements at each stage so that information could flow between cartographer and user more efficiently. The goal, as with all communication, was clarity (Crampton, 2001: 237).

The early communication models

Although John Keates (1925–1999) had introduced the idea of maps as communication devices at a London meeting in 1964 (Board, 1981), the first published map communica-tion model was devised by Moles (1964) and followed by Board (1967). As Board (2017: 32) explains, the communication paradigm ventures to make explicit all operations in the crea-tion of maps and the generalized communication system encapsuled the essence of the way in which many practising and thoughtful cartographers saw their role.

The most influential early contribution to the development of a scientific model of map-making was put forward by Koláčný (1969) (**Figure 1**). According to MacEachren (1995: 4), Koláčný's depiction of cartography as a communication system had the greatest initial impact and the justification for this 'cartographic communication model' was based on his concern to address the hitherto neglected area of utilization. As Koláčný (1969: 47) states, 'so far
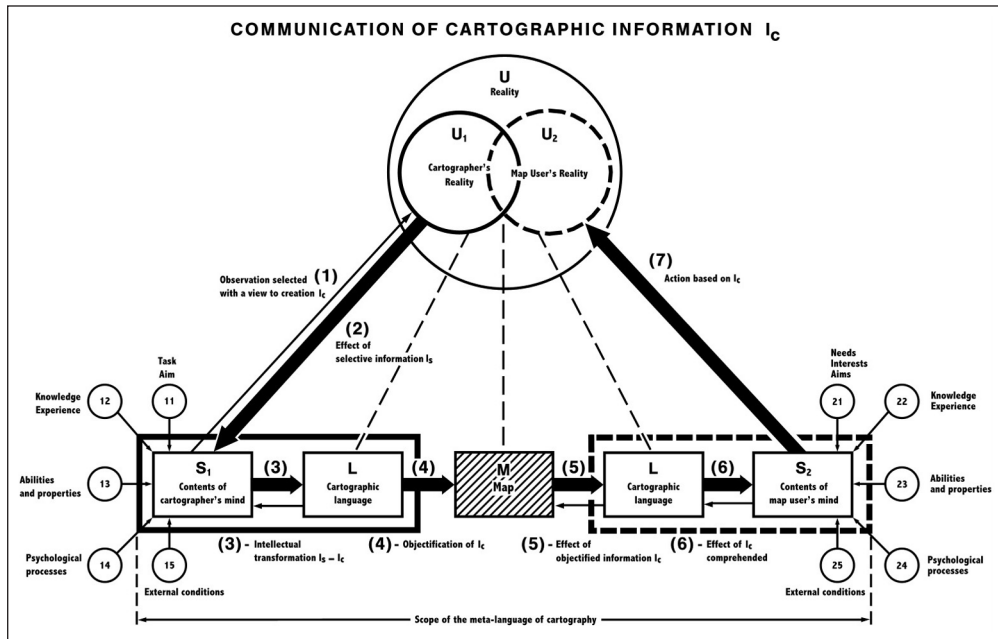
Figure 1: Koláčný's (1969) diagram of the map communication model (redrawn from Koláčný, 1969 and reproduced courtesy of the British Cartographic Society).

cartographic theory and practice have been concerned almost exclusively with the creation and production of cartographic works. One would hardly believe how little attention has been given until recently to the theory and practice of map use'. As the starting point for his model, Koláčný took the cartographer's 'selective observation of reality', from which a transformation of 'the multi-dimensional intellectual model of reality' to cartographic information takes place through the 'language' of map symbols. These are read by the map-user and translated into cartographic information, leading to the user's model of reality, which is then processed into an idea. Koláčný's (1969) diagram long served as a basic model (Keates, 1996: 113) and as can be seen, it attempted to include a variety of factors affecting the use of maps within the scope of the 'meta-language of cartography'. The central concept of the entire process was the transfer of 'cartographic information' (Koláčný, 1969: 49).

Research into the possibilities of automated cartography increased and further investigations into information theory gave rise to attempts to calculate the amount of information that a map was carrying. For example, Sukhov (1970) considered calculations of information quantity and entropy as worthwhile means for designing content and generalization, claiming 'The map is not only an imprint, but also a power information carrier. This remarkable feature of the map makes grounds for the application of information theory in cartography generally and in generalisation particularly' (41). He also considered the mathematization of map contents to be a 'necessary condition' for the complete automation of every process in map and atlas plotting (46). This faith in the communication theories to provide answers to the problems of map design was strongly affirmed by Koeman (1971: 172), who remarked that 'most of our cartographers invent and apply their own rules and do not seem to know of the universal validity of the communication-doctrine'.

The successful implementation of the communication paradigm meant that by the 1970s, the quest to establish a conventional model of cartographic communication, incorporating

the whole gamut of the cartographic process from map-making to map-reading, had become the dominant theme in cartographic research (e.g., Balasubramanyan, 1971; Petchenik, 1974; Robinson and Petchenik, 1975; Robinson and Petchenik, 1976; Board, 1977; and Petchenik, 1977). These theories of cartographic communication essentially attempted to reveal the connections between the creation of the map as one set of processes and obtaining information from the map as another (Keates, 1996: 111), but at their root was the premise that the map was a tool for imparting information to the user. Koeman (1971: 171), for example, defined the function of a map 'in the widest sense' as communication. By determining its function, the cartographer could evaluate various options in designing a map with new confidence and meant that the dichotomy of cartographic success or failure appeared to take on a clearer rationale.

Development of the communication models: Noise and Gestalt

Communication models were developed further by including concepts dealing with the loss of information in the process between map-maker and map-user. Treating cartography as a formal communication system meant that the function of the map could be improved by reducing the loss of information at various points in the system (MacEachren, 1995: 5). Robinson and Petchenik (1975) built upon the communication theories by examining how the more fundamental elements of the map operate within a communications system. They introduced the concepts of 'encoding', 'transmission', and 'decoding' to the communication of cartographic information, while referring to the notion of 'noise' as an inhibitor to the process. Amongst variables such as lighting conditions and printing quality, the level of noise present in the system could also be affected by symbol design. Their contributions to the theories of cartographic communication culminated in the publication of *The Nature of Maps* (Robinson and Petchenik, 1976). Perhaps seeking more pragmatic aspirations, their work suggested to a wider audience that when the meaning of a map is expressed through badly designed symbols and therefore becomes unclear to the user, the communication between cartographer and user fails and the meaning of the map, itself a symbol of reality, is lost.

Building upon the concept of error in map communication (an approach taken earlier by Jenks and Caspall, 1971), Dobson (1985: 41–42) argued for a shift in emphasis, stating that while models of cartographic information systems are in vogue, it is the cartographic error system that is of central importance. The primary responsibility in handling maps was therefore to manage error technically and with skill (Pickles, 2004: 33).

So, for cartographers, improving the efficiency of cartographic communication meant improving individual symbol design and reducing unnecessary information, while also being sensitive to map-reading conditions. An awareness and control of the factors inhibiting the basic function of the map would therefore be the key to its success; noise was to be eliminated in pursuing the goal of greater cartographic efficiency.

In focussing on user responses to cartographic design, empirical research largely embraced the psychology of visual perception (e.g., Dent, 1972 and Cleveland et al., 1982) and, together with an awareness of the physiological apparatus of seeing, aimed to understand the ways in which people perceive maps. An influential theory of perception was Gestalt, which originated in the late nineteenth century and held that visual stimuli that are adjacent tend to be grouped together into wholes (*Gestalten*). A particularly relevant aspect of the theory was the perception of figure and ground, which may be summarized as follows:

> Whenever we open our eyes we see, not sensations of light, but objects and surfaces. There is a tendency (most easily noticed in vision) to organize our percepts in a certain manner during all perceiving: we effortlessly distinguish between the figure in a field of view and the ground against which it is seen (Gordon, 1997: 64–65).

By organizing the map elements as either figure or ground, the cartographer could direct the user's attention to certain symbols. Any features distracting the user from the main theme, through the use of bold colours for background areas for example, could give a false impression of figure and so could also be classed as noise. The careful application of visual weight to symbols by colour and size, for example, would suggest a 'visual hierarchy' of features. The appropriate application of colour and line thickness to roads could suggest their relative importance and, if the figure-ground relationship was suitable, this would ensure that the roads seemed nearer to the user than the urban and rural backgrounds or other features such as rivers. This would also ensure that roads and their classes were perceived with due attention – an essential requirement if the map was to be designed for road users.

It was thought that Gestalt theory could assist the cartographer in reaching for the goals defined by the communication models. According to Gordon (1997: 67) 'The Gestalt theorists had concluded that there must be a general underlying principle behind the numerous examples of organization. It was as if perception tended, wherever possible, towards simplicity, symmetry and wholeness'. It was also felt that the theory might provide a useful benchmark: 'one does not need to be taught to perceive correlated patterns or regions on a map. These results are consistent with [the] claim that visual perception is a universal constant' (Muller, 1981: 7). However, although the models of cartographic communication were rapidly adopted (Wood and Keller, 1996: 22), the search for a universal model proved to be elusive.

Limitations of the map communication models

As the map communication models continued to develop, they became more diverse in character and shared little agreement on what actually constituted each fundamental element of the communication process, such as map interpretation. It is therefore difficult to describe the exact development of the map communication models for, as Board (1981: 55) states, 'By the mid-1970s any historical account of the development of models of cartographic communication becomes unmanageable very largely because of their increasing popularity and the way in which authors making use of them learn and borrow ideas from one another'.

A unifying theme across the communication models in their 'optimization' of the cartographic process was their encouragement of the inclusion of the fewest themes, shown in the simplest way possible. Southworth and Southworth (1982: 16) follow a similar canon in their guidance for designing successful maps: 'no one map can serve the needs of all users [...] the purpose of the map must be narrowly and precisely defined and then every bit of data that is not essential to this purpose must be strictly excluded'. Such an approach does not lend itself easily to the design of topographic (or general-purpose) maps, however, where several different types of information (e.g., hydrology, relief, urban areas, transport networks, vegetation, and tourist features) are traditionally to be displayed simultaneously and in detail. This difficulty is reflected in the increasing bias towards the advancement of thematic (or 'special-purpose') cartography as the communication models developed into the late 1970s.

The attraction of science was not limited to the discipline of cartography, with Board (1981: 70) recognizing that the professionalisation of cartography occurred roughly simultaneously with the adoption of the scientific paradigm within geography. The post-war hegemony of modernism valued reductionism and the determination to unveil objective truth; progress was based on the assumption that knowledge of the essential parts would lead to knowledge of the whole. Information theory therefore became popular with those concerned with the ideas of cartographic communication because it allowed the elementary function of a map – the transmission of cartographic information – to be isolated. The success or failure of a map therefore depended upon its ability to transmit information effectively. As Crampton (2001: 237) explains, under the map communication model, the goals of cartography were

to produce a single, optimal map, which presented information clearly and which was based on known factors of map use.

Following these models then, the efficiency of the map-reading process largely relied upon the cartographer's selection of abstract symbols when describing a subject; each symbol's design as an effective expression of its meaning; and how easily this meaning would be understood or recognized by the user, according to the user's level of skill under certain environmental conditions (e.g., lighting). For the practising cartographer, communication theories were concerned with improving the map as a product and it is not hard to see why these ideas had strong commercial connotations. Cartographers want to know how best to meet the needs of the user and the implementation of these findings within working practice is compatible with the aim of selling more maps. Keates (1996: 190) reminds us that in any field which is concerned with making things, the means of making them is of vital concern. As with any product, it must be designed to meet certain needs:

> Cartographers are paid to make maps not because anyone particularly wants maps as maps, but because map buyers have information needs that maps allow them to meet. Maps are created because of these needs, not (as the theoretical models often have it) because a cartographer has some conception of reality that he wishes to communicate to some hypothetical user (Petchenik, 1985: 9–10).

Until the 1980s, the notion of information transfer remained the dominant paradigm in cartographic theory. The bulk of research continued in its aim to understand how to create better maps by being more effective at communicating the message of the map to particular user groups. Keates (1996: 122) was later keen to point out various deficiencies in this approach, stating that what a map offers is a possibility, not a message; the wealth of human experience and knowledge, and the infinite ways in which a map's array of symbols are interpreted, cannot be limited to a closed system.

Map users are different, and to a certain extent (sometimes great), they look at and think about maps differently (Montello, 2002: 295). Symbols can be connotative as well as denotative; while the denotation of a symbol is that to which it explicitly refers, its connotations are a totality of recollections evoked by it (Morgan and Welton, 1992: 35). Different symbols can therefore mean different things to different people, and the value of these meanings, which are constructed by the reader of the map as well as by its maker, were largely ignored by the functionalist drive of the communication models. The role of experience, memory, and imagination in the map-reading process (and how they might influence interpretation) was typically overlooked in the reduction of the user to a component of the model. MacEachren (1995: 459) suggests that these communication models floundered due to their fundamental assumption that maps act primarily as a 'vehicle' for the transfer of information, which in fact matched only a small proportion of mapping situations.

While most cartographers would have continued to agree with Koláčný (1969: 47) that 'A modern product of cartography is required to present objective information about reality conceived in spatial relations, in a true and telling way', rather ironically, other disciplines demonstrated some awareness of the implications of cartography's inherent subjective dimension. For example, Aziz (1978: 50) had pointed out that by selecting some features and ignoring others, maps act like cultural expressions indicative of the society that produced them, while almost a decade later, Axelsen and Jones (1987: 461) insisted that 'every map is the product of a particular, socially conditioned conception of space, and therefore a mental map'. Even so, the idea of mapping as a social practice eluded cartographers, and when alternatives to scientific positivism arrived, their boldness unsettled the discipline of cartography.

The critical reading of maps during the last decades of the twentieth century occurred during a period when scientific positivism was being challenged. As Pickles (2004: 27) explains, 'profound epistemological changes have shaken the self-understanding of the sciences and humanities as Cartesian dualisms and scientific naturalisms of all kinds have been brought into question. The result has been nothing short of a "crisis of representation"'. Through Derrida came deconstruction, which gathered momentum as a means of intellectual enquiry, infiltrating and probing disciplines whose values had previously stood unscathed. The traditionally held view of cartographers, the pursuit of one, universal, and absolute truth, was no longer a stable fortress in which they could seek refuge; the cartographer's truth was just one view of the truth, it could be examined, scrutinized, and discarded like any other.

Technological developments and the rise of the user-cartographer

Advances in the development and accessibility of desktop publishing technology, the rise of Geographical Information Systems (GIS) and the availability of cartographic information through the internet have provided the user with more potential power and control over geographic visualization than ever before. The internet became a major medium for cartography since the mid-1990s, with the widespread use of the World Wide Web (Peterson, 2007: 35). Web mapping made it more feasible than ever for members of the public to collect data, design maps, and disseminate these maps to global audiences (Muehlenhaus, 2014: 18), yet institutional producers tended to make more aesthetically pleasing maps (p.32). Crampton (2001: 236–237) went as far as to say that with the advent of electronic maps and geovisualization, the drive for creating the optimum map is no longer relevant:

> Harley and GVis [geographic visualization] indicate that mapping should proceed through multiple, competing visualizations which are not created by a cartographer and transmitted to the user but made on the spot by the user acting as his or her own cartographer. In other words, the search established by Robinson for the single optimal map through ever-clearer methods of map communication is over.

Technology has indeed developed to allow users to make their own digital maps (and to print them in colour), using a compilation of base and thematic data and so map-makers rarely make decisions on how best to meet the needs of the user. As Montello (2002: 298) notes, amateur 'cartographers' who make widely disseminated maps do not make use of basic cartographic principles in the first place. Nevertheless, maps require a map user to be made meaningful, even if in some cases the map user is the same person as the map-maker (Griffin, 2017: 44).

The new millennium has also brought some colossal changes in the ways that maps are made, shared and used. These include access to greater levels of accuracy with global navigation satellite systems (GNSS) (in particular, the removal of the Selective Availability error from the US constellation of Global Positioning Satellites in 2000), the emergence of OpenStreetMap in 2004 as an online global map created through the collaborative capture and rendering user-acquired data, and improved accessibility to global imagery and maps with the launch of Google Earth and Google Maps in 2005. The wider availability of mapping technologies, location-based services, governmental geographical data and volunteered geographic information (VGI) since the beginning of the new millennium has been accompanied by a resurgence of the role of art in cartography, for example, where the visualization of geographic data now extends to mapping the ephemeral (Kent and Vujakovic, 2017).

Towards a new map communication model

Although propaganda maps have been treated as exceptionalist and exempted from theories of maps and cartography (Pickles, 2004: 40), map communication models have left a legacy of user-orientation in map design and still form the basis for aspects of cartographic research. The simpler models continue to act as vehicles for considering the various factors surrounding map use, and for the practitioner, treating the map as a carrier of information offers a useful approach to understanding how maps work. Even in the latest (sixth) edition of *Elements of Cartography*, it is suggested that the principal task of cartography remains 'to communicate environmental information' (Robinson et al., 1995: 17), and the paradigm is often used to instruct about how to make better maps, for example by Brewer (2016) and Darkes and Spence (2017). In general, 'communication' still forms a useful frame of reference for discovering ways in which the user can be better served, and the cartographer's task improved, thereby providing a useful paradigm for the purposes of educating future cartographers.

Aside from their limitations outlined above, the map communication models paid relatively little attention to feedback, an essential step in a communication system. Without feedback, it is difficult to know if the message was received and/or understood. With regard to cartography, feedback can offer insights for refining the map's design. At the time the map communication models were developed, maps were designed to be disseminated in the same format and appearance as when they left the printer. Today, the cartographer has much less control over how their maps are seen, by whom, when and where. Variations in screen size, format, resolution, colour and brightness allow for a multitude of viewing experiences, while global dissemination can be achieved faster than ever before. If Koláčný (1969: 47) was right in that a map has to satisfy the consumer's needs and interests, it could be argued that the current trend follows a natural progression in the path to fulfilling that goal; the impetus behind this technology being the empowerment of the user-as-cartographer.

It is the advent of social media, however, which presents both a significant challenge and an opportunity for cartographers. As Robinson (in press) explains, social media has become a critical vector through which people communicate ideas, opinions and news. Facebook, the social networking service, has around 2.2 billion active users per month (Statista, 2018a); Instagram, the image- and video-sharing service, around 800 million (Statista, 2018b); and Twitter, the micro-blogging service, around 336 million (Statista, 2018c). These and other social media channels allow maps to be uploaded as images to the user's account as 'posts', which can subsequently be liked, shared and commented upon by others, and 'pushed' to casual observers' social media accounts via the map-makers' accounts they follow. Free mapping tools, data sets, and tutorials combined with social media dissemination vectors make it possible for non-experts to quickly create and share maps with very large audiences (Robinson, in press). Indeed, maps are ideal for dissemination – and consumption – via social media; their graphical format provides an immediate visual summary that can stimulate as well as inform or misinform, since complex spatial patterns are communicated in an instant (Kent, 2017: 193).

If likes and shares provide some form of 'virtual endorsement', this raises pertinent questions for the use of feedback as a measure of success that also has wider implications for the function of cartographic design. Chilton and Kent (2016) discovered that communication appears to be an implicit goal for neocartographers, who listened to feedback and regarded the number of tweets/likes/shares as a good indicator of the success of their cartographic design, to the point of influencing the conception and design of their future maps. This capacity to respond to user feedback (by issuing successive map revisions) is a marked characteristic of mapping in an age of social media. It is, however, interesting to note that positive media get shared more widely than negative (Berger and Milkman, 2012; Guadagno et al.

2013) and according to Lee et al. (2016), the most salient motives for clicking on 'Like' on Facebook were for enjoyment or for pleasing others. In their investigation to determine what makes an image popular, Khosla et al. (2014: 870) examined the number of views on Flickr as a medium in a study using 2.3 million images and found that image content plays a role, finding that greenish and bluish colours tended to have lower importance than reddish colours, which the authors suggested was because more striking colours tend to catch the eye of the observer and lead to a higher number of views. Nevertheless, in addition to content, the level of attention a post receives depends on the account holder's status (e.g. the number of their followers), as their followers see the posts they share. Hence, a map shared by a well-known celebrity is likely to be seen by thousands, if not millions, regardless of the quality of its design.

While it is clear that feedback via social media offers a substantial opportunity for cartographers to identify the level of engagement with and reactions to their maps, it should be borne in mind that the majority of these maps are not encountered during the process of searching for information. Robinson and Petchenik (1976) used the term 'percipient' to distinguish those users who deliberately sought answers from maps. Hence, feedback originating from a task-oriented user is likely to have a different bias to a casual observer who encounters and shares a map just because they find it interesting and/or it arouses emotion. For video, Guadagno et al. (2013: 2317) found that the emotion of joy was the most significant predictor of whether a video would be forwarded, supporting the idea that high-arousal positive emotion trumps all other effective factors in determining one's choice to forward a video.

Robinson (in press) acknowledges that there is a tendency for social media to focus at least as often on entertainment value as it does on the dissemination of news. As maps present evidence holistically and aesthetically and media are more likely to be shared if they arouse a positive emotion, the design and dissemination of maps via social media may simply be driven by entertainment. If the divide between news and entertainment has become blurred, so has the distinction between the cartographer and the user. We live in a data-driven society with 24-hour news cycles, so maps of any variety simply have less staying power online; the stories they tell and the arguments they make are fleeting and rapidly forgotten (Muehlenhaus, 2014: 31).

Cartographers today, therefore, require a sound theoretical basis that incorporates the cartographer and the user (rather than separating them) in the journey of communication and optimising map design. The endurance of the cartographic communication paradigm has demonstrated the value of its basic premise of information transfer via the map, even if mapping and map use are processes of knowledge construction rather than transfer (MacEachren, 1995: 459). In contrast with the map-making processes of the 1960s and 1970s, however, cartography today is much more interactive, both between the map-maker and the map, and between the map and the user.

Figure 2 presents a new map communication model that aims to reflect the greater agency that users have in shaping map design and communication today. Although the cartographer and the user are divided by the point of dissemination and feedback, they are linked in dialogue through the processes of creation and engagement, which are symbiotic and inter-dependent. The model aims to suggest the map's ongoing refinement in response to user feedback and the creative solutions that might be pursued in light of these by the cartographer, with notional start and end points introduced by the conception by the cartographer or organization and the onward sharing of the map by the user. This acknowledges the technological developments of digital mapping that allow substantial design changes (e.g. colours and lineweights for several components simultaneously) to immediately be made on screen. The map-making and editing process today is much more responsive to the aesthetic judgements of the user and the cartographer, so that as the design evolves as a whole, entropy
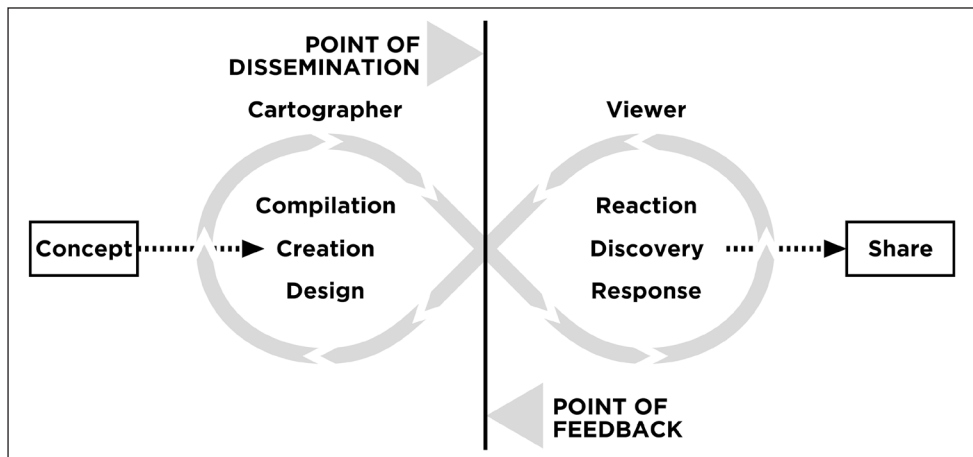
Figure 2: A new map communication model.

(the possibility of error from a random variable) is reduced. Once the map has been disseminated, the cartographer has less control over the form it might take, for example, by users copying and amending the design (perhaps evolving as a visual meme), or depending on how it is shared, whether the map reached at source via an embedded link, allowing the results of successive updates (in response to feedback) to be seen.

The model recognizes that maps are continually in a state of flux and that they mean different things to different people. Instead of reducing the process of communication to the transmission of a single unit of information, it aims to celebrate creativity and diversity in cartography as maps evolve and flourish. If social media offers scope to examine the emotive power of maps, understanding how emotion is communicated and transferred may help cartographers better respond to the needs of society and create something more meaningful. This also embraces the artistic value of maps and the way that cartographers see and present the world.

Robinson's (1952) vision that maps can be made more effective through their visual aesthetic is insufficient to distinguish the professional from the amateur today, given the mapping tools available to user-cartographers. Although maps present evidence visually (and hence engaging with maps is an aesthetic process), it will be the cartographer's ethical principles that set them apart (British Cartographic Society, 2018). Hence, the promotion of communicating truthfully, with openness and good design, should provide something of an antidote to the virus of poor cartography. Following the advice of Speier (1941: 311), if propaganda by maps should be fought with other maps rather than with words, cartographers should disseminate good cartographic design as widely as possible through social media channels while considering accurate and meaningful user feedback. Identifying the latter may be based on studies such as Agichtein et al. (2008), who were able to determine high-quality content on social media from user-generated responses in Yahoo! Answers and discovered that the length of the answer was significant. In turn, this would help cartographers to design maps that better leverage our contemporary means for dissemination and engagement (Robinson, in press).

Conclusion

Maps are made and re-made through communication, a paradigm which was developed after the Second World War and whose theoretical framework endures in practical cartographic texts today. Since the first map communication models were devised in the 1960s and 1970s,

however, cartography has lacked a sound theoretical framework upon which practitioners can build their pursuit of optimising maps. Although the epistemological break introduced by Harley (1989) eventually supplanted the communication paradigm with critical cartography, the ensuing distrust of cartography and cartographers has not been deterred by new insights into the processes of geovisualization and their rationalization of the journey from data to information (e.g. MacEachren, 1995).

Drawing a parallel with the stimuli of the first map communication models in the need for cartographers to create maps that are more effective, relevant and trustworthy amidst the widespread dissemination of poor cartography (in this instance by individuals rather than states), a new map communication model was presented in this paper. Taking technological innovations (such as the availability of software mapping tools and data) into account, it places a focus on user feedback and the enhanced dialogue between map-maker and map user in an age of social media. It is proposed that cartographers should use social media to create and disseminate good cartography, informed by user feedback. This is especially important, when more map-makers seek to make curiosity-driven maps for the purposes of entertainment at a time when the boundary between entertainment and information is blurring.

There is scope to develop the model presented here further and to examine how feedback from social media may be utilised more effectively to inform better map design and communication. In particular, there is substantial potential to explore whether the design values of casual observers and expert cartographers coincide and more specifically, whether 'shareability' is different from popularity in terms of how maps are disseminated. There is further scope to understand map-viewers' aesthetic preferences in situations of non-use and to investigate whether maps are liked or shared for different reasons than are other visual media such as photographs or videos. This may, in turn, reveal new insights into the nature of maps and what makes them particularly distinctive within the wider realm of graphical communication.

Competing Interests
The author has no competing interests to declare.

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