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Users’ Perspectives About the Potential Usefulness of Online Storylines to Communicate River Research to a Multi-disciplinary Audience

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ABSTRACT

Effective communication practices are needed to support adaptive, collaborative and integrative environmental management. We propose the use of online storylines to communicate scientific outcomes in a way that is captivating, easily understood and accessible. Based on 20 interviews, we identified important attributes for the storyline content, structure and user interaction. We designed a storyline example about stakeholders’ perceptions of a river management intervention with consequences on the landscape. The intended audience consists of multi-disciplinary researchers and practitioners that could consider or apply research solutions outside their field of expertise in river management. We introduced the example in a workshop with 14 participants from research and practice. Our findings highlight the importance of including narrative elements via images, interactive figures and timelines to illustrate the research context. Moreover, storylines should explicitly state benefits as well as the limitations of the river research and include a glossary to clarify specific terms.

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Multi-disciplinary communication; narrative elements; river management; user-centered design

Introduction

Increased socio-technical complexity has created challenges for environmental management, which researchers argue needs to be adaptive (Pahl-Wostl, 2008), collaborative (Pratt Miles, 2013) and should integrate different types of knowledge and disciplines (Krueger et al., 2016). This requires more effective communication to inform and engage multi-disciplinary actors in the discussion of potential solutions to these challenges (Moser, 2010; Owen, Macnaghten, & Stilgoe, 2012). However, the often large temporal or spatial scale of environmental problems, such as global warming, may decrease the sense of urgency of management actors or affected stakeholders (Weber, 2006). Low risk perceptions of environmental problems may affect their interest to take action (Buchecker et al., 2013). Active dissemination of underlying assumptions, methodological choices and related uncertainties is required to facilitate learning about problem complexity and potential science solutions (Wibeck, 2009). Avraamidou and Osborne (2009) further highlight that research outcomes

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are traditionally communicated via argumentative approaches, such as journal papers and reports, whose language, diagrams and structure are an integral part of the scientific discourse. However, this information structure makes it difficult for other stakeholders such practitioners to identify and understand the scientific contribution to practice.

In this context, online and interactive communication tools and technologies can facilitate (Maurel et al., 2007): (i) access to information; (ii) active reflection and elicitation of perspectives; (iii) sharing of information and knowledge exchange. Two-way communication, i.e. knowledge exchange and interaction, between researchers and stakeholders contributes to the development and application of potential solutions to environmental problems (Lindenfeld, Hall, McGreavy, Silka, & Hart, 2012). Interactivity is a key factor in face-to-face relational processes that have been implemented at different levels in online technologies to improve the interaction between both the user and the tools and between users (Chung, 2008). Researchers themselves and science communicators may benefit from interdisciplinary, user-driven and participatory approaches to better understand communication needs of research and practice, for example by involving potential users in the design process (Zulkaflı et al., 2017).

Recent studies suggest the use of narratives to communicate scientific facts, experiential knowledge and ethical considerations (Ingram, Ingram, & Lejano, 2017; Keller, Siegrist, & Gutscher, 2006); to facilitate user engagement and discovery through interactive exploration (Stephens, DeLorme, & Hagen, 2014; Wozniak, Lück, & Wessler, 2015); and to develop a common vision or shared understanding about the problem definition and potential solutions (Dieperink et al., 2016). Hinyard and Kreuter (2007, p. 778) define narratives as “any cohesive and coherent story with an identifiable beginning, middle, and end that provides information about scene, characters, and conflict; raises unanswered questions or unresolved conflict; and provides resolution.” Narratives approaches such stories, storytelling and storylines are emerging as important tools for environmental communication (Moezzi, Janda, & Rotmann, 2017). Narratives can be formally written and told by professionals (Christensen, Åberg, Lidström, & Larsen, 2018) or be less formally exchanged via short stories or in a more personal way (Kurtz, 2014). The storyline term often refers to the unifying theme of a narrative as opposite to the detailed content (Moezzi et al., 2017). However, Moezzi et al. (2017, p. 3) also refer to storylines as the narrative analysis method to “decompose a [detailed content, argument or] discourse into simpler framings around which actors and institutions organize themselves and create meanings” (Moezzi et al., 2017). Storytelling can thus be used as a generic term to communicate a way of understanding and influencing others. Such understanding can be communicated by presenting the experiences of interacting characters (Dahlstrom, 2014) or a sequence of events, facts and observations linked into a unifying theme (Segel & Heer, 2010).

Storylines have been used as communication mean to: (i) analyze policy frameworks (Jones & McBeth, 2010); (ii) reveal and analyze the specific cases of how actors construct meaning and act upon environmental problems (Ingram, 2014); (iii) analyze and simplify components from a broader policy discourse into a meaningful account to mobilize action (Smith & Kern, 2009); (iv) analyze and present the sequence of key variables or processes, events and actors to describe (future) management scenarios of water systems (Bruijn, Lips, Gersonius, & Middelkoop, 2016; Dong, Schoups, & van de Giesen, 2013; Haasnoot, Middelkoop, Offermans, Beek, & Deursen, 2012). Referring to Birks, Mills, Francis, and Chapman (2009), we understand storylines as a simplified translation of a wider narrative or detailed scientific argument into its core elements. Further research is needed to understand the use and role of narrative approaches in science communication (McBeth, Lybecker, Stoutenborough, Davis, & Running, 2017).

In this study, we propose storylines to communicate the context, outcome and importance of river research in a way that is captivating, easily understood and accessible. Our research aim is to elicit users’ perspectives about the potential usefulness of online storylines to communicate river research. The intended audiences are multi-disciplinary researchers and practitioners that could further consider or apply science solutions outside their own field of expertise. To that end, we first present the theoretical background and refer to the key elements of a communication process to frame our
storyline approach. Next, we describe the research setting and methods, including (i) semi-structured interviews; (ii) a design example; and (iii) workshop with potential users. User requirements derived from the interviews were used to prepare the design example that was further evaluated in the workshop. This section also presents the feedback from the evaluation workshop. Finally, we discuss our findings and the limitations of our study to conclude with the implications for research and practice. As such, this study reports on the first stage of developing online storylines using a user-centered design approach (van der Bijl-Brouwer & van der Voort, 2014). In such approach, each stage of the design has an explicit focus on the users and their needs by involving them in the design process. Applying a user-centered design approach to the storylines enables improving these iteratively and participatory based on users’ opinions and input.

**Theoretical background**

This section outlines the key concepts in environmental communication and narrative approaches which formed the basis for our study. Fiske (1990, p. 2), defines communication as the “social interaction through messages.” Communication starts by understanding the intended audience and identifying the reason for communication and expected outcome. Communication objectives or expected outcomes include awareness raising, upsurge stakeholders’ understanding of a specific topic and moving audiences to take action (Höppner, Whittle, Bründl, & Buchecker, 2012). Involving multiple stakeholders as intended audiences implies considering the possibility of variable interpretations of expected outputs, the need for trust-building and cooperation between actors, and the diverse practical rationalities of researchers and stakeholders (Boholm, 2009; Brugnach & Ingram, 2012).

Environmental science communication often involves communication of risks and uncertainties (Wibeck, 2009). Risk communication refers to the transmission of messages and the relational process of creating and exchanging meanings, which according to Boholm (2009) need: (i) a common language by which meanings are articulated and shared; (ii) verbal and non-verbal expressions that must be understandable by all actors in the communication process; (iii) consideration of the context of the communication process. Storylines can be an effective way to capture such meanings in science communication. Moser (2010) lists eight key elements which need to be taken into account for an effective communication process. Below we describe how these elements are included in our storyline approach.

- **Purpose:** Narratives have four distinctive capabilities (Kreuter et al., 2007, p. 221): (i) overcoming resistance to information presented; (ii) facilitating information processing by learning from experiences; (iii) connecting to the audience by relating to familiar elements; and (iv) addressing emotions. By tapping in these capabilities, the storylines include distinctive narrative elements such as questions and answers, images of the study area and fieldwork as well as interactive figures to communicate river research outcomes.

- **Scope:** The scope is related to the purpose of communication and may vary in type and number of users, time period and level of engagement. We are designing an online knowledge-base with storylines as a main component to engage water professionals in river research in learning more about the potential use of research outcomes in practice.

- **Audience:** In river management, our audience can be defined as direct and indirect users of research outputs such as fellow researchers and practitioners (McBeth, Lybecker, & Stoutenborough, 2016). Those are generally professionals working in research institutes, private or governmental organizations among other representatives of stakeholder organizations.

- **Messenger:** In science communication, messages are commonly sent from the researchers’ side (information provision). Communication about environmental problems and of potential solutions require multi-disciplinary, interactive and two-way communication (consultation and dialog) to improve knowledge uptake and societal impact (Lemos & Morehouse, 2005). Our goal is to improve one-way communication by addressing a multi-disciplinary professional audience and enable consultation by collecting feedback about the potential use of river research.
• **Message and framing:** In multi-disciplinary communication, messages are about different research topics and include a variety of methods and outputs. In our study, research outcomes include datasets, guidelines and modeling outputs presented as maps and/or charts. According to Fliervoet and van den Born (2017, p. 3), framing theory refers to the way to “construct meaning, and how the different frames play a role in finding common ground (or not).” The storyline message is framed following a sequence of questions and answers about the research context and case study application. Meaning is derived from the combined representation of research outcomes with narrative elements such as the overarching theme, the cause-and-effect sequence of the processes studied, the temporality of the events that take place (Dahlstrom, 2014; Phillips, 2012).

• **Modes and channels of communication:** Online tools facilitate communication with users at different locations, at (a)synchronous time and with access to different resources (Maurel et al., 2007). Narratives use a wide range of (or a combination of) content and forms in which the storyline is told (Hinyard & Kreuter, 2007). Our storylines combine visual and written elements with some level of interactivity via online navigation options.

• **Effectiveness:** Narrative elements can be used in a wide range of media and the combination affects both the storyline itself and its effectiveness. To evaluate effectiveness, user-centered design generally uses both formative and summative evaluation (Hix & Hartson, 1993; Scholtz, 2004). Summative evaluations focus on evaluating whether a design meets measurable performance goals and user requirements, related to for example effectiveness. Formative evaluations are performed as intermediate evaluations that aim to enhance its performance and inform design choices. Our study reports on the initial design of the storylines, based on user interviews, and formative evaluation via a workshop with users as a first step of the iterative design process.

**Methods**

We aim to elicit users’ perspectives about the potential usefulness of online storylines to communicate river research. To meet this goal, we use user-centered design methods combined with an iterative design process and formative evaluation, which are suitable methods if targeting multiple end-users or usage situations (McIntosh et al., 2011). Usefulness can be defined as the information and interaction that meets users’ roles and interests in river management (Zulkaflı et al., 2017). We understand potential usefulness as the requirements that a storyline should meet for effective design (van der Bijl-Brouwer & van der Voort, 2014).

Our general approach follows the road map proposed by Gemert-Pijnen et al. (2011) for the development of online tools, which consists of five phases: contextual inquiry, value specification, design, operationalization and summative evaluation (Figure 1). Our study focuses on the first two phases and addresses how contextual inquiry can be used as an input for the next research step that is the value or benefit specification of the storylines. In the remainder of this section, we first describe the research setting and outline the methods used to (i) elicit users’ perspectives; (ii) apply them in a design example; and (iii) discuss the example in a group setting.

**Research setting**

In lowland areas like the Netherlands, flood safety has historically sparked many river interventions. Most recent management strategies, such as Room for the River, aim for sustainable and multifunctional use of rivers and floodplains by combining flood protection with nature development and improving landscape quality (Herk, Rijke, Zevenbergen, Ashley, & Besseling, 2015). RiverCare studies the mid-term effects of river interventions to reduce maintenance needs and to increase benefits for biodiversity and ecosystem services. The program comprises 8 projects (Figure 2) grouping 21 researchers each with a specific topic in either hydraulics, geomorphology, ecology or environmental management (Hulscher, Schielen, & Augustijn, 2016).
To increase the outreach in the Netherlands and abroad, our goal is to effectively communicate research outcomes with representatives of knowledge institutes, consultancies and government organizations (i.e. potential users). A knowledge-base is designed to provide access, explain and gather feedback about the potential use of results to professionals interested in river management. The knowledge-base is a website with a content management system in which the storylines are the main component. Other components include hyperlinks to underlying research data and other websites that present our results via news, fact sheets, reports and journal papers.

**Interviews with potential users**

To identify the requirements that a storyline should meet for its potential usefulness, we conducted semi-structured interviews with 20 potential users in a two-month period (May and June 2016). We...
selected participants who were involved in the Ecosystem Services and River Governance projects (Figure 2) because they represent a multi-disciplinary audience. In addition, we interviewed two representatives of international partner organizations due to their interest in RiverCare outputs. We distinguish user groups according to the participants’ affiliation. The 20 participants worked at research or academic institutions (RE = 7), government authorities (US-AU = 4), consultancies (US-PR = 6) and other stakeholder organizations (US-SH = 3). The scope of the interview was broader than only the storylines and was divided in three parts to identify participants’: (i) experience in working with multiple actors in river management; (ii) potential usefulness of the knowledge-base including the storyline component and previous computer experience with similar online tools; and (iii) expectations and perceived drivers to access RiverCare knowledge and to share own experience or interests. Interviews were carried out in English and lasted for about two hours each. This study reports on the analysis of interview questions in which the storylines component was explicitly discussed (6 questions; part 2). The first and last part of the interviews are reported in a separate study and were only used in this study as a context to interpret the results.

To gather users’ perspectives about the storylines, we first gave a short introduction into its use: “Interactive and easy to follow storylines will be used to share the RiverCare objectives or results with a wider audience. Along the storyline, you can access links related to RiverCare results and join available discussions,” and showed them a schematic representation (Figure 3). After the introduction, we asked three scoring questions using a 7-point Likert scale from 1 (strongly disagree), 4 (neither/either) to 7 (strongly agree); and three open-ended questions to provide comments (Table 1). The interview guidance for the storyline part is available in the supplementary material (Appendix A1).

During the interview, scores and comments were reported in a guidance document and double-checked with participants. Twenty interviews were transcribed verbatim and analyzed. One interview was carried out with two participants as that was the preference of the interviewees. The recording of one additional interview was not successful and therefore not considered into the analysis. One interview was not fully carried out and not included in the analysis as the participant expressed his/her work was not directly related to RiverCare outputs. Scores from interview participants were split into three categories: low agreement (scores 1 and 2), undecided (scores 3, 4 and 5) or high agreement (scores 6 and 7). The intermediate options represent a neutral position and therefore do not
hold much information. The distribution of interview participants among user groups and their reported scores are also available in the supplementary material (Appendix A2). Due to the limited availability of information in the scores, user requirement analysis rather focused on the open-ended questions. For the analysis of interview transcripts, we followed the approach of Gemert-Pijnen et al. (2011): (i) formulate codes identifying what attributes are useful; (ii) group codes to summarize requirements; and (iii) formulate value propositions about expected benefits of users. The following considerations were taken into the analysis:

- The first author (also interviewer) developed the coding scheme based on reported comments in the guidance document and further reviewed it when analyzing the interview transcripts. The coding scheme grouped comments by similarity and requirements were identified by grouping multiple related codes.
- The second author reviewed the coding scheme by reading the transcripts, assigning codes, and comparing the two sets of codes. Based on this comparison some codes were merged or re-assigned.
- The frequency of a given code was counted for each group of participants. We equally acknowledged the contribution of all comments regardless of how many times comments were brought forth in the same interview by only counting them once.

### Design example

Based on the results from the interviews, we prepared an example storyline for one of the RiverCare research projects. The design example describes the research on stakeholders’ perceptions (i.e. local residents, recreational fishermen and boaters, and shipping professionals) of a river management intervention with a high impact on landscape qualities. This research was selected due to the availability of results in the form of reports, fact sheets and journal papers. More detailed information about this study and the area can be found in Verbrugge, Ganzevoort, Fliervoet, Panten, and van den Born (2017). The storyline example was prepared out of the distinctive elements of research outcomes such as actors, case studies and proposed solutions framed in the form of questions and answers via online text, visuals and interactive charts with navigation. The storyline example was implemented using a fast prototyping software (Articulate Studio 360). This software allows deploying the storyline in a browser; easy customization of text and images; and provides some navigation options.

### Evaluation workshop

To identify the strengths and weakness of our storyline approach, we discussed the design example with potential users during a workshop session, which took place in November 2016. Participants to the workshop were both researchers (including some RiverCare researchers) as well as representatives from authorities and consultants. One of the participants was also interviewed in the first part of the study. The workshop was held during a RiverCare dissemination event, and consisted of 40 minutes divided into: (i) a short introduction (15 min); (ii) interaction with the storyline example in subgroups of two (or three participants) sharing a laptop (15 min); and (iii) a wrap
up (10 min). Subgroups reflected upon the objectives of the storyline example via an anonymous feedback form. For the workshop evaluation, we used a five-point Likert scale as the design example was more concrete than the storyline introduction. Workshop participants rated the following statements questions from 1 (fully disagree), 3 (neither/either) to 5 (fully agree):

Q1. The storyline was useful to:
   a. Explain the why the research was done
   b. Give examples about how results can be useful
   c. Get contact details and access related links
Q2. The storyline was clear and easy to follow
Q3. The storyline can be useful for water professionals in the Netherlands and abroad
Q4. The storyline can be applied to results in ecology and geomorphology

We added two open-ended questions so that participants could highlight strengths and weaknesses of our storyline example. The feedback form and summary of workshop scores and comments are included in the supplementary material (Appendix B). A video to the storyline example that was discussed during the workshop is also available in Appendix C as part of the supplementary material.

Results

**Storyline attributes and user requirements**

Most participants in the interviews were either undecided or positive about the storyline introduction and its potential usefulness to communicate RiverCare research (Table 2). Participants’ distribution for the question about the previous experience (10 participants in low and 7 in undecided) highlights their unfamiliarity with storylines as described in the interview guidance (Figure 3). When asked for examples of tools, interviewees mentioned a range of different media in which storylines can occur, such as videos, project websites with discussion fora, visually attractive elements and databases. One of the researchers mentioned that pilots or cases studies could be presented as storylines “So they split up in different environments, different cases, project phases, and they add examples. And the examples can be like the storylines.” A researcher and a practitioner with a high level of experience attempted to create storylines themselves, in the form of videos or storyboards for software design.

Table 3 shows the absolute frequency of attributes that emerged from the coding scheme that we used to analyze the interview transcripts. The frequency is not a direct indicator of importance and only shows the number of times an attribute was mentioned considering all participants. We grouped attribute codes into three type of requirements related to the storyline’s content, structure and user interaction. Regarding content, most participants suggested to have a concrete example to reflect upon (N = 13) and agreed that the storyline needs to present the results in a simple and clear context (N = 12). Furthermore, they expressed the wish to see the added value of the research (N = 9), and that the information needs to be tailored to different user groups (N = 11). The latter was mentioned by the majority of participants with a research background (6 out of 7). As one researcher puts it: “the information that we try to communicate sometimes has to be formulated in a different way to

<table>
<thead>
<tr>
<th>Scoring questions</th>
<th>Low (Scores 1 and 2)</th>
<th>Undecided (Scores 3, 4 and 5)</th>
<th>Positive (Scores 6 and 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreement level with the storyline introduction*</td>
<td>–</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Usefulness for the interviewees’ work or interests</td>
<td>1</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Previous experience with online platforms including this component</td>
<td>10</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

*Score for one participant was not reported in the guidance document.
be able to communicate with other stakeholders.” Five participants further highlighted the need to specify the audience of the storylines.

Eight participants emphasized the need for fast access, as well as easy to follow navigation and search options. Six participants suggested to show the project overview, timeline and users’ involvement. Less frequent yet important, one researcher required further clarification about the target audience, goal and specific output of a discussion element next to the storylines. Another participant (government representative abroad) suggested that collecting feedback about the storyline is important and that he/she “would expect that I share something on this platform and then get feedback from users.”

When asked about usefulness of the storylines, a participant affiliated to a research institute referred to the storyline as “a nice illustration of the problem or solution […]” However, that requires that the storyline is, has at least a message for the customer.” A participant from a government authority abroad suggested to create the storylines as examples of research applications so it can be used to engage stakeholders of a particular project whereas a participant from a government organization in the Netherlands was interested to learn more about the results instead. Participants from consultancies would use it as a guidance “to get access as soon as possible to the new knowledge, to the added value for me” whereas for examples in their field of expertise they would prefer to access available publications. Finally, one of the participants from a stakeholder organization highlighted that river management “affects many actors but not all actors can access the information. So it will be really useful.”

**Design example**

For an initial evaluation of our storyline approach, we developed a design example of one RiverCare storyline. Based on the content requirements identified in Table 3, we made the following design choices for the storyline example (Figure 4). The example was deployed in a browser using the layout
of the prototyping software and included three tabs: storylines, contact details; and resources and publications.

- The storyline content started with an introduction to the specific research aim and was written from the perspective of consultants or river managers. To guide the users, the storyline was divided in four sections each with a heading question.
- As for the navigation structure, we used a slideshow with annotated chart options. Links to contact details and more technical information were also included in the contact details and resources tabs.
- As for the user interaction, users can explore the results presented in the form of interactive quotes and charts. Options for a feedback form and glossary of terms were foreseen but not active or elaborated for the design example.

**Feedback from the evaluation workshop**

We received seven completed feedback forms filled in by subgroups of 2-3 workshop participants, including one that did not specify the number of participants. Figure 5 shows an overview of the feedback. Average scores above the neutral position were given to usefulness for professionals outside the Netherlands (Q3 = 3.3); the applicability to other research topics (Q4 = 3.6) and the availability of contact details and related links (Q1c = 4.4). All subgroups appreciated the interactive elements in the storyline design, including pop-up texts and photos. However, points of criticism both in the scores and comments were to better explain why the research was done (Q1a = 2.3) and how these results can be useful to the users (Q1b = 2.6). For the storyline clarity and ease to follow, the average score (Q2 = 2.7) represents the need for improvement, for example by a more sequential timeline approach and a clarification of terms. Additional feedback suggested to make the connection with the underlying datasets and to include in the storyline missing stakeholders such as nature authorities.

**Figure 4.** A video to the storyline example that was discussed during the workshop is available in Appendix C as part of the supplementary material.
Discussion

Our results from qualitative interviews, a design example and an evaluation workshop provide insights into users’ perspectives about the potential usefulness of our approach. Storylines are tools to communicate with multi-disciplinary researchers and practitioners so that they can identify relevant aspects for their work or interest. As a general recommendation, interview participants required a more specific example to reflect upon. Therefore, we prepared such example for further discussion and evaluation in a workshop session. Table 4 summarizes the value or benefits for users in terms of three overarching principles: the content, structure and user interaction requirements. Here, we discuss the interview results and workshop feedback to shed more light on these three principles.

Ease of understanding

Workshop participants were critical but recognized the potential usefulness of the online storyline to communicate with a multi-disciplinary and non-specialized professional audience in the research discipline. Participants referred to the low recognisability of terms in the storyline content and highlighted the importance of combining factual statements and narrative elements. Suggestions were to

Table 4. Value propositions identified from the interview analysis.

<table>
<thead>
<tr>
<th>Storyline requirements</th>
<th>Description of value propositions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ease of understanding</strong>: Understandable (clear, simple and recognizable context of the results) for the various user groups. In addition, the storyline should show the benefit and case study context of the research.</td>
<td></td>
</tr>
<tr>
<td><strong>Easy access to useful and relevant information for various user groups</strong>: Relevance is indicated by the relationship with the specific research, project, case study, organization or professional network.</td>
<td></td>
</tr>
<tr>
<td><strong>Easy to follow and with interactive elements for overview navigation and feedback</strong>: Include visually attractive, easy to follow, interactive and dynamic elements. Include possibility to provide feedback.</td>
<td></td>
</tr>
</tbody>
</table>
explicitly state the benefit and potential use of the research as opposed to leaving these as implicit (or “hidden”) elements in the storylines.

Referring to the recognisability of terms, Christensen et al. (2018) suggest to use simple vocabulary and metaphors that relate to everyday life while limiting sensational framing. Camporeale, De Nicola and Villani (2015) suggest to use sharable concepts and categories between multi-disciplinary fields. Whenever necessary, the specific terms should be clarified in appendices or glossaries. Referring to the combination of factual and narrative elements, Avraamidou and Osborne (2009) acknowledge that narrative approaches can potentially enhance interest and understanding of scientific facts which are central to the storyline. Such combined and explicit preference for the storyline content follows Birks et al.’s (2009) definition of a simplified translation to its core elements.

For an improved storyline example, challenges are to balance the simplification and outline of core elements without diminishing the credibility and validity of research outcomes (Freshwater, 2009). Such challenges also apply for storytelling in general as narrative elements can be intrinsically persuasive (Dahlstrom & Ho, 2012). Warner and Buuren (2011) highlight that scientific outputs can have multiple interpretations as there might be different values and interests in the projected results by affected stakeholders. In their empirical studies on communication preferences, McBeth et al. (2016) suggest to frame content by highlighting good practices in river management. Krause and Bucy (2018) highlighted that despite the power of visual frames, images alone do not dictate how individuals construct meaning, and should not be used in isolation when targeting individuals who are undecided on an issue. Covi and Kain (2016) pointed out that descriptions of setting characteristics and location may not ease understanding of scientific information but may raise people’s interest in environmental problems. We, as researchers and science communicators or mediators, should further acknowledge that presenting research outcomes to a targeted audience requires some degree of simplification and framing of research results and therefore it is important to communicate both benefits and limitations of the results.

**Easy access to useful and relevant information**

All potential users that were part of our study considered easy access to additional links and contact details important. In addition to the contact details and related publications links, workshop participants also requested a link to the research questions, underlying datasets and framework of the research program. Easy access also relates to the transparency of scientific information for the trustworthiness of the communication (Hall Jamieson & Hardy, 2014; Matthews, 2015). Therefore, it is important to include links to the underlying reports or other evidenced-based information as well as acknowledging the remaining challenges of scientific findings. Whether or not such background documents are actually consulted by different audiences requires further study. Joint efforts between science communicators, journalists, designers and researchers can improve storyline content and enable easy access to useful and relevant information (Lindenfeld et al., 2012; Nisbet & Fahy, 2015). The storyline content and structure can further benefit from narrative psychology approaches to define the integral narrative elements such as setting, character, events, means, purpose and dilemmas (Murray & Sools, 2015).

**Easy to follow interactive elements, navigation and feedback**

Users’ perspectives on interactivity refer both to their navigation in the storyline and the opportunity to send feedback to the program team. Workshop participants appreciated the combination of images and interactive charts. However, they also suggested two options to simplify the navigation; (i) to provide a (printable) overview; and (ii) to include elements referring to the timeline of the river interventions or the research activities in the storyline structure. The structure needs balance the level of online user interaction and navigation options that could potentially increase user engagement and discovery (Stephens et al., 2014).
In our study, one interview participant highlighted that reacting to an element without specifying (i) the goal, (ii) the response time frame, or (iii) engaging in face-to-face interaction may limit the possibility to reach a shared understanding. For the latter, Dincheva, Ernst, and Raja Boean (2015) propose to further use narrative approaches as part of face-to-face and collaborative processes. Bruijn et al. (2016) also suggest that storylines may provide a basis for discussion with stakeholders, for example on the main contributions of research, its assumptions and remaining knowledge gaps. As such, potential users can be motivated to share their understanding of or experience with the applicability of the results (Ny, MacDonald, Broman, Yamamoto, & Robért, 2006).

**Study limitations**

Following a user-centered design approach, the results from the interviews represent perspectives and communication preferences from professionals related to or directly interested in the program outputs. Therefore, this study did not include preferences from wider professional networks which may have provided a more diverse range of opinions. However, in line with Dyer et al. (2014), we recognize that participatory approaches should balance early engagement with meaningful and timely impact in the process and outcomes. This study is the first step of a design process to define objectives and minimum requirements to communicate with the program stakeholders via storylines.

The planning of the workshop was constrained in time and place and this may also have affected our results. Due to the strong relation with the RiverCare dissemination activities, the design example was prepared during the interview analysis and focused on the content-related attributes. The design example layout was a stand-alone component limited to the options available in the prototyping software, which possibly affected participants’ opinions during the workshop. In addition, time during the workshop was limited and it is possible that not all participants had time to read the storyline in detail as we intended. However, limited time availability reflects the time that they would spend on reading the storyline in reality.

**Concluding remarks**

This study proposes the use of online storylines to communicate river research outcomes and elicit user perspectives about the necessary attributes for usefulness. Our findings highlight both advantages and challenges of narrative approaches and result in the following general recommendations for the development of online storylines to communicate research to a multi-disciplinary audience:

- Combine explicit statements and narrative elements into the storyline for ease of understanding, easy access and engagement. The benefits and limitations of the results should be explicitly stated, and narrative elements (e.g. images and interactive figures, maps and timelines) combined to illustrate the research context or the study area.
- Define your target audience and explicitly invite them to interact with the storylines. In addition, researchers and practitioners in the specific field could use storylines as a complementary communication tool to explain their research or to familiarize themselves with results outside their field of expertise.
- Start with formulating the guiding questions of your storyline structure. It is important that guiding questions and specific answers are formulated from the perspective of the audience (in this case river management). This can be done by highlighting (1) relevant indicators for decision-making and (2) the relevance for application or case study implementation.

Limited to our case study, we learned about the need to improve both the storyline’s clarity and navigation while linking them to other components of the knowledge-base. Evaluation of communication efforts distinguish between content, process and outcomes (Rohrmann, 1992). Therefore,
next research steps should also focus on refining the evaluation measures for the content and quality of the storyline, as well as the design process. Outcome-based evaluation should not only monitor the online usage (Charrière & Bogaard, 2016) but the effectiveness in terms of the interest of users in, understanding of and access to our research outputs. Process-based evaluation can take into account the users’ experiences in the design process, as well as the impact of their engagement on the intermediate prototypes. In addition, the usage of storylines to support face-to-face meetings can have a purpose for facilitating a shared understanding of the research outputs and should be studied for this reason.

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Availability of data
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