Learning and Collective Knowledge Construction With Social Media: A Process-Oriented Perspective

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Social media are increasingly being used for educational purposes. The first part of this article briefly reviews literature that reports on educational applications of social media tools. The second part discusses theories that may provide a basis for analyzing the processes that are relevant for individual learning and collective knowledge construction. We argue that a systems-theoretical constructivist approach is appropriate to examine the processes of educational social media use, namely, self-organization, the internalization of information, the externalization of knowledge, and the interplay of externalization and internalization providing the basis of a co-evolution of cognitive and social systems. In the third part we present research findings that illustrate and support this systems-theoretical framework. Concluding, we discuss the implications for educational design and for future research on learning and collective knowledge construction with social media.

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In the last few years, the impact of social media on people's lives has increased in a variety of contexts. Nearly everybody encounters these technologies constantly and is involved in social media activities in some way—such as reading and commenting on entries in other people's blogs (e.g., Jung, Song, & Vorderer, 2012), looking up definitions and information on Wikipedia (e.g., Schweitzer, 2008), collectively tagging digital resources (Held, Kimmerle, & Cress, 2012), exchanging information in Internet forums (e.g., Kimmerle, Gerbing, Cress, & Thiel, 2012), or communicating with friends and acquaintances on social

networking sites such as Facebook (e.g., Park, Lee, & Kim, 2012). *Social media* provide technologies that support interaction and collaboration among users, allowing them to build communities and exchange content. This phenomenon has inspired numerous educational researchers and practitioners to think about how social media might also be usefully applied for teaching and learning purposes (Friesen & Lowe, 2012; Mao, 2014; Ravenscroft, Warburton, Hatzipanagos, & Conole, 2012).

The interaction and collaboration processes supported by social media take place on the Internet (therefore, the term “social web” is frequently applied in this context; e.g., Ravenscroft, 2009). They occur in highly informal scenarios where intrinsic motivation and personal interest often guide people’s epistemic activities (Schroer & Hertel, 2009; H. L. Yang & Lai, 2010), and where collaboration develops as a bottom-up, self-organized process of active participation. These conditions make it quite difficult to transfer collaboration with social media directly to formal educational settings (e.g., Ravenscroft, 2009), which are, not always but typically, characterized by fixed curricula and instructional guidance (Kirschner, Sweller, & Clark, 2006). Moreover, on the Internet, social media support interaction and collaboration not only among small numbers of people but also among very large groups of users. These groups are not institutionally predetermined like students in a class but form themselves autonomously in terms of networks of people or as communities. In these groups people usually do not interact primarily because they aim to learn something (even though this may sometimes also be the case, of course) but because they perceive the interaction itself to be rewarding.

In the early days of the attempt to transmit social media processes to educational settings, there was a euphoric hope of being able to transfer Internet users’ verve and enthusiasm to the classroom (Baird & Fisher, 2005). There was little awareness of the differences between formal and informal situations, however, and few appropriate theoretical considerations were available. More recently, most researchers and designers of learning environments have become aware of these issues and their consequences and have accordingly reflected on social media use in educational settings more cautiously (Andersson, Hatakka, Grönlund, & Wiklund, 2014; Friesen & Lowe, 2012; Ravenscroft et al., 2012). In the review presented here, we aim to support this recent development and make a contribution to a more differentiated theoretical analysis of the use of social media and of the cognitive and social processes to which they might contribute.

From the perspective of educational psychology, it is interesting and relevant to examine in what ways and to what extent social media may contribute both to learning as an individual process and to *collective knowledge construction* on the Internet, in the classroom, or through any form of interplay between formal and informal situations. These interactive processes of collective knowledge construction

occur when a group of individuals creates new understanding by taking up each other’s contributions and combining them into new insights. This may happen spontaneously in short-term groups, but also in communities that form themselves around intellectual or practical challenges and epistemic problems (see the communities of practice concept; Lave & Wenger, 1991). Such communities mostly act autonomously, organize their own structures and collaboration, and use technology in order to meet particular challenges and problems. In such situations, the community as a whole develops and constructs new knowledge while the community members also individually advance and refine their own knowledge. So individual learning and collaborative knowledge construction are interdependent and occur simultaneously.

The intent of this review is to provide some tentative theoretical answers to the following questions: How are social media currently being used for educational purposes? In what ways do social media promote individual learning? What are the processes involved in the collective construction of knowledge with social media? How is individual learning related to collective knowledge construction?

In the following sections we provide a three-part analysis. In the first part, we review literature on the use of social media in educational contexts. Many authors focus on technological aspects and specific functionalities of particular tools. In addition, they seldom consider the underlying processes and activities, which is not satisfying from a psychological point of view. Therefore, we present in the second part a perspective that spells out the cognitive and social processes social media can induce. Because social media were not developed for instructional purposes but rather to support communities, we suggest a process-oriented perspective that allows us to analyze how individual learning and collective knowledge construction are intertwined. For understanding these processes, we propose a systems-theoretical approach that refers to self-organization, to the development of individual and collective knowledge through processes of internalization and externalization, to the interplay between the knowledge of individuals and that of a community, and to further key concepts. In the third part of this paper we provide a summary of research findings regarding those processes and concepts. Concluding, we discuss the implications of our theorizing and empirical findings for the application of social media in educational settings and for further research on this issue.

SOCIAL MEDIA IN EDUCATION

The fast transformation of the Internet into a social web (O’Reilly, 2005) has been due to technological shifts, such as the use of browsers instead of desktop applications, the development of mobile technology, and the availability of cloud computing. As a result, tools and services like wikis, social networking sites, online forums, blogs, and social

tagging tools have become relevant not just in everyday life but also in the context of learning and education. These technologies, tools, and services also can influence the way people learn, share information, and construct knowledge (Kolbitsch & Maurer, 2006). Users may actively participate in communication with others and be involved in the creation of content (e.g., by contributing to wiki articles, publishing personal profiles, participating in forum discussions, writing blogs, and tagging resources). The distinction between consumers and producers of content ceases to exist (Bruns, 2006), as everyone can use social media to publish one's own knowledge in an easy and cheap way. As a consequence, social media enable the collaboration among large numbers of heterogeneous users (Tapscott & Williams, 2006). The online encyclopedia Wikipedia is an example of just such a mass collaboration (Cress, 2013a, 2013b; Halatchliyski, Moskaliuk, Kimmerle, & Cress, 2014): A multitude of voluntary users construct the world's largest encyclopedia based on wiki technology.

The idea of using social media for collaboration has been adapted in several other contexts, such as in knowledge management (Levy, 2009; Matschke, Moskaliuk, & Cress, 2012), politics (Etling, Kelly, Faris, & Palfrey, 2010), marketing (Sashi, 2012), or citizen science (Robson, Hearst, Kau, & Pierce, 2013). Collaborative social media are also causing changes in formal learning settings, for example, where a class of students sets up a Facebook

group for distributing course-related announcements, sharing documents, or the like (see, e.g., Wang, Woo, Quek, Yang, & Liu, 2012). From an educational perspective, this development is highly relevant, as it may have an impact on how people learn. On one hand, individuals may benefit from the enormous quantity of information available on the Internet that is accessible everywhere using different devices and mobile technologies. On the other hand, social media provide the opportunity to participate in collaboration within (large) communities.

There have been many attempts to transfer social media applications to educational settings. In appraising the suitability of such transfer endeavors, educators have to consider the particular peculiarities of the Internet context and the educational context with regard to adaptability of social media (Table 1 provides an overview of some characteristics of both contexts).

Popular tools for the transfer to educational settings are *wikis*. Wikis are web sites that allow users to contribute and change content easily online (Leuf & Cunningham, 2001). In wikis users can modify existing text, insert new content, delete or restructure the whole text or parts of it, and link existing and new content using hyperlinks (Moskaliuk & Kimmerle, 2009). Many researchers have considered wikis powerful tools for educational purposes. In educational contexts, wikis have been used as tools for individual writing tasks (e.g., Allen & Tay, 2012), as well as for collaborative

TABLE 1
Comparison of Some Characteristics of the Internet Context With the Educational Context in Terms of Social Media Adaptability

<i>Internet Context</i>	<i>Educational Context</i>
Large masses of users are potentially available for participation; given a large group of users, a relatively small portion of active contributors may be sufficient for a community to be able to work well.	Often only a small group of users is available (e.g., a class or course). → Potentially, larger groups of users could be incorporated (such as an entire school or university or several institutions), but this has so far been unusual.
Social media users are largely free in their choice of activities (whether, how, and to what topic they want to contribute); nevertheless, community-specific demands and guidelines exist that cannot be easily modified or ignored by single users.	Often curricula, externally predetermined learning goals, and learning assessments are firmly established. → But many educational interventions seek to make instruction much less top-down; social media processes might be more suitably applicable to those more student-centered inquiry processes.
Users share particular interests or concerns, which may lead to joint activities.	Students in a class are not necessarily interested in the current instructional subject per se. → But in many student-centered approaches teachers concede the choice of (sub)topics or pursuit of individual questions to their students.
High level of self-organization is required, that is, users have to establish their own rules, organize their own structures and collaboration, and regulate their workflow and activities on their own.	For students in a formal educational institution, it is difficult to see any necessity for self-organization since rules and activities are often already largely institutionally specified. → Recently, however, many educators grant their classes more freedom in organizing themselves as communities.
Social media provide the opportunity for relating one's own experiences, and expressing ideas, thoughts, and comments.	When students are strongly geared toward achieving specified learning goals and receiving good grades, their own thoughts may play a minor role compared to rehashing teacher-determined learning material. → But most educators nowadays explicitly invite students to introduce their own concerns, which might be more compatible with the requirements of social media collaboration.

writing (e.g., Forte & Bruckman, 2006; Larusson & Alterman, 2009).

In most cases, however, the use of wikis in educational contexts does not harness the full potential of the original idea of tools for mass collaboration on the Internet. Instead, adaptation of the technology is usually limited to small groups of students (e.g., Li & Zhu, 2013) and used with established curricula, externally predetermined learning goals, and learning assessment. Therefore, many applications in small groups fall short of opportunities for the *self-organization* that is often successful in wiki communities on the Internet: In such self-organized communities users establish their own goals and rules, organize their own structures and collaboration, and regulate their workflow on their own. In self-organized wikis on the Internet, users come together as a result of a common interest or concern and are then required to organize their common activities in an autonomous, self-directed, and independent way. This is much less frequently the case in the classroom. A similar problem applies to *Social Networking Sites* (SNS), which are mainly known for the opportunity they provide for people around the world to generate user profiles and connect to other users (Cress, Schwämmlein, Wodzicki, & Kimmerle, 2014). This is what they have been designed for and how they are predominantly used (e.g., Ellison, Steinfield, & Lampe, 2007). So despite the fact that their potential for educational purposes has been pointed out frequently (Dawley, 2009; Selwyn, 2007), the academic applications of SNS are not necessarily related to genuine learning.

Instead, SNS are primarily used for *auxiliary activities*, such as organizing meetings and managing project groups (Madge, Meek, Wellens, & Hooley, 2009), sharing information about instructions or deadlines (Greenhow & Robelia, 2009), and exchanging course materials (Wodzicki, Schwämmlein, & Moskaliuk, 2012). *Blogs*—personalized web pages where authors write their experiences, ideas, thoughts, and comments—often deal with private and personal issues, but there is a substantial and even increasing number of people using blogs for academic purposes (Powell, Jacob, & Chapman, 2012). S.-H. Yang (2009) even referred to blogs as “learning spaces.” In their review of the literature, Jimoyiannis and Angelaina (2012) identified various characteristics that can be found in educational blogs: They can serve as online course management tools, discussion forums, and e-portfolios. They may enable group blogging and provide project-based environments. However, the significance of *communication* and *collaboration* using blogs (e.g., commenting on the blogs of others) remains largely unclear.

We assert that researchers and practitioners do not yet really understand how individual learning and collective knowledge construction relate to each other. The potential of social media can be observed in informal settings on the Internet. These are settings in which the knowledge acquisition of individuals is not foremost but rather a by-product of the community-related activities. We argue that to

understand the potential of social media for education, we have to focus not only on the learning processes of individuals but also on the collective processes that take place in the community of users. Technologies should be examined in terms of their influence on these individual and collective processes, rather than as means and ends in themselves. In the following, we suggest a process-oriented perspective that describes social media as means for self-organization, considers the individual as well as the collective level, and explains how both interact. In a nutshell, we argue that social media allow for conceptualizing learning and knowledge construction as two sides of the same coin. The particular potential of social media is that they induce and support co-evolutionary processes that couple individual learning and collective knowledge construction.

A PROPOSAL FOR A PROCESSES-ORIENTED PERSPECTIVE

We argue that it is necessary to conceptually distinguish collective knowledge-related activities from individual learning activities. Roughly speaking, individual learning may be considered to be an internal process that takes place in an individual mind and results in modifications of individual knowledge and beliefs, or skills and abilities. Collective knowledge construction, in contrast, refers to a process in which new public knowledge arises and is developed further by a community (see Murphy, 2007; Scardamalia & Bereiter, 2003). Learning as an individual activity has been examined extensively in psychological research for more than a century. The collective process of knowledge construction, however, is a topic that has started to attract more and more attention during the last two decades (e.g., Nonaka, 1994; Scardamalia & Bereiter, 1994). But so far, both approaches have not been integrated into a larger framework. In the following, we briefly refer to theories that may be applied for understanding individual and collective knowledge-related processes and we explain which theoretical considerations provide a basis for our process-oriented research approach to learning and collective knowledge construction with social media.

Individual and Collective Knowledge

Technological support of knowledge-related collective processes is not a recent development. Many organizations had already developed computer networks in the 1980s to support the dissemination of information within an organization (Daft & Lengel, 1986; Sproull & Kiesler, 1986). Collecting information is important for the transfer of knowledge between individual members of a group (Kimmerle & Cress, 2008, 2009) and may lead to collective knowledge construction, when existing information is restructured and integrated into new ideas at the collective

level. To explain *how* groups can think and develop new knowledge, the notion of groups as information-processing entities came up in the 1990s in social and organizational psychology (Hinsz, Tindale, & Vollrath, 1997; Klimoski & Mohammed, 1994). Groups were described as problem-solving units (Larson & Christensen, 1993), for example, where social interaction enables the acquisition, storage, transmission, manipulation, and use of information for the purpose of group-level judgments and decisions. Pertinent tools were developed to support group-level information processing, such as group decision support systems and shared repositories where users could make their information available to others. After all, the models developed in this research tradition are based on the *information-processing approach*, where knowledge as such remains located in individuals and interaction merely aligns the cognitive representations of the people involved.

In the learning sciences, in contrast, *socio-cultural frameworks* that conceptualize all kinds of learning (not just collaborative learning) as a social activity became relevant. They localize knowledge not only in an individual but also in the culture and environment where the individual is embedded (e.g., Järvelä & Hadwin, 2013; Stahl, 2006). Activity theory (Engeström, 2001), for example, conceptualizes knowledge as an interaction of individuals with cultural artifacts like tools, symbols, and language as the central mode of learning. The distributed cognition approach (e.g., Hutchins, 1995) is based on a similar idea: Knowledge and cognition are distributed across tools and artifacts, as well as across other individuals. Learning is shaped by interaction with the environment, and the distributed knowledge needs coordination and integration.

A theory that puts a particularly strong focus on the collaborative aspects of learning is *knowledge building*. It expands upon research on collaborative writing and conceptualizes learning as a collective process, where a group of learners jointly develops new knowledge (Hewitt & Scardamalia, 1998; Scardamalia & Bereiter, 1994, 2003). Knowledge building describes the collaborative construction of knowledge, which is usually supported by using computers and shared digital artifacts. Discourse within a group leads to the common construction of knowledge and contributes to the development of collective knowledge (Scardamalia, 2002). The group constructs knowledge not only by sharing individual knowledge with other members, but also by sharing mutual experiences within a common (often digital) environment. Knowledge building is characterized by a variety of principles (Chan, 2013; Scardamalia, 2002), of which some also appear to be applicable to learning and collective knowledge construction with social media. The principle of epistemic agency, for instance, emphasizes that learners explain their ideas and need to debate about to what extent their individual ideas fit those of others. In doing so, they do not simply complete given tasks but aim to collectively modify each other's ideas, which then leads to idea

improvement—another crucial knowledge-building principle. It comes along with learners' understanding that ideas are knowledge-related entities that are not fixed once and for all but may be examined, analyzed, and improved. In this process the group elaborates on problems that the community as a whole considers to be relevant, which in turn leads to the emergence of community knowledge. It is a crucial aspect of the knowledge building account to conceive of knowledge as community property rather than the mental content of an individual (Scardamalia & Bereiter, 2010). A similar argument has been put forward in other contexts that investigated (mass) collaboration. Hardwig (1985) presented the case of a scientific publication with 99 authors and raised the question as to whom one might attribute the knowledge in the publication. Although this might be an extraordinary example, publications with dozens of authors are not unusual. Consider, for example, research from the European Organization for Nuclear Research (CERN), which is made possible only by the collaborative efforts of the many people involved. But does that mean that all of the contributors know every relevant detail about the project? Probably not. Rather, it is likely that people with different backgrounds contributed their expertise, and thus the collective knowledge of this project (regarding how it was conducted as well as its results) rests with the group. In other words, none of the group members alone would be able to replicate the project. Only the group (or a group of people with the equivalent sum of expertise) could accomplish this. Following from these considerations, Hardwig (1985) proposed that groups, not individuals, might be the bearers of knowledge (see also Faulkner, 2006). This argument is even more reasonable in view of the fact that the expertise of any one scientist relies heavily on the knowledge, ideas, and observations that have been obtained by others (Hardwig, 1985) and that progress and growth in knowledge essentially results from collaboration (Oeberst, Kimmerle, & Cress, in press; Popper, 1968).

The possibilities for such mass collaborations have substantially increased with the emergence of social media (Cress, Jeong, & Moskaliuk, in press; see Gowers & Nielsen, 2009, for the collaborative solution of a math problem). Wikipedia, for instance, as a comprehensive compendium of world knowledge, has been collaboratively compiled and constructed by thousands of volunteers. Those contributors have investigated what is currently known about a particular topic, presented this knowledge in an encyclopedic (i.e., objective, neutral) way (see Oeberst, Halatchliyski, Kimmerle, & Cress, 2014), and have linked it to information within and outside Wikipedia. So Wikipedia as a whole is borne by a mass of authors who adhere to the rules of Wikipedia. In a related way, one might argue that collaboratively constructed knowledge may also reside in a shared artifact that resulted from this collaboration (e.g., the scientific paper, a Wikipedia article). Popper (1968) even went beyond this notion. He suggested that thought *contents* exist independently of any person, whereas thought *processes*

were bound to individuals. In other words, a mathematical proof exists regardless of whether some person has discovered it. These approaches and considerations make clear that individual learning cannot be sufficiently described as a cognitive process only but must be conceived of as a process that takes place in a social environment.

An approach that may be eligible for bridging the individual-oriented information-processing tradition with sociocultural frameworks is *argumentation* research. This research considers exactly those processes that are described in the knowledge-building approach, that is, integrating different information and ideas, weighing them, and finding a convincing conclusion (Chinn & Clark, 2013; Fischer et al., 2014). Argumentation is part of school curricula. The general idea of argumentation research is that when students work together and exchange arguments, they not only stick to their own understanding but may take up other's ideas and develop a deeper understanding. When people encounter new ideas, they need to adapt their own concepts and contribute to a collaborative development of understanding (D. B. Clark & Sampson, 2007). In this vein, collaboration is more than sharing or transferring ideas. Collaboration enables individuals to come to insights that none of the individual group members had before. Such emergent phenomena are addressed in the seminal work by Roschelle and Teasley (1995), who described how a group of students suddenly came to a new understanding of a physical concept as a result of mutual explanations. Stahl's (2006) concept of *group cognition* also took into consideration such *magic moments*, when groups come collectively to new insights. In the knowledge-building framework, such pivotal moments are described as part of the idea-development process (Law & Wong, 2003). This highly dynamic and collaborative process is not only determined by what students already know or introduce into the collaborative situation, but also a vibrant process that happens in a given situation where the people involved assume *cognitive responsibility* (Zhang, Scardamalia, Reeve, & Messina, 2009). Through discourse, new ideas come up, and over time particular ideas survive, whereas others notions become extinct. All these processes happen through self-organization. It is the group itself that defines what information is acceptable, what makes sense, and what ideas should be dismissed. The group decides whether an idea is valuable. Valuable ideas become part of the discourse and influence further utterances. At an early phase during an interaction, an idea may be seen as valuable, whereas later on the same idea may be interpreted as incorrect. The flow of interaction is dynamic; it is not predetermined by the single users or by anyone guiding the interaction.

Besides the collaborative output, previous research has also identified several potential benefits of argumentation for the individual learner (for an overview, see Chinn & Clark, 2013). Participating in argumentation enhances motivation (Chinn, Anderson, & Waggoner, 2001),

supports learners in developing content knowledge (Andriessen, 2006), and improves their argumentation skills (in general and with regard to a particular topic; Chinn, 2006). These benefits apply to computer-supported argumentation as well (e.g., Kuhn, Goh, Iordanou, & Shaenfield, 2008, showed improvements in metalevel communication and in reflecting on goals in this context).

Our perspective on knowledge construction takes the same approach as knowledge building and argumentation research, which both set out to describe the epistemic activities between individuals and a collective in more detail. We consider how people integrate different knowledge strands into one more or less coherent line of argument. We aim to explain how people contribute their own knowledge to the group, how others take it up, and how the group infers new knowledge out of the different contributions. We regard communities as central incubators for developing new knowledge, and we analyze how these communities trigger individual learning of the participants involved. We argue that a feasible analysis should not only distinguish between individuals and communities but also describe how they depend on each other. We need to observe individual and collective processes in detail, describe their interdependence, and analyze how they interact (see Järvelä, Volet, & Järvenoja, 2010). All these considerations lead us to the conclusion that what we need here is an approach that allows (a) considering individual cognitive processes and (b) considering social processes as units of analysis, but also (c) examining the interplay of both types of processes while (d) connecting to other relevant theories, such as knowledge building and argumentation. Accordingly, we suggest basing a process-oriented perspective on the use of social media in educational contexts upon systemic considerations with which we can distinguish between cognitive and social systems but also analyze them simultaneously. In the following, we shortly describe key concepts of systemic approaches before we apply them to learning and collective knowledge construction with social media.

Systems Theoretical Considerations

Systems theories provide promising approaches to deal with highly dynamic and self-organized processes. Various systems theoretical approaches have been developed since the middle of the 20th century (see von Bertalanffy, 1950) that deal with the question of how individual components at a lower level establish systems on a higher level. This question applies to a multitude of contexts, such as the relationship and the interplay of cells and organisms, waves and lasers, or individuals and groups. Systems are entities that exist in specific environments to which they need to adapt in order to maintain their existence. Systems theory also deals with the question as to what extent a system is closed or open to its environment and how exchanges between system and environment take place.

Regarding living systems, the concept of *autopoiesis* was introduced (Varela, Maturana, & Uribe, 1974). An autopoietic system is defined as a system that constitutes and produces itself. Notably, this conceptualization posits not only that units at a lower level establish a higher level system (e.g., cells establish a biological organism) but also that the higher level system produces and re-produces the units at the lower level (the biological organism produces the cells it consists of). As we outline next, this concept of autopoiesis can be nicely used to understand cognitive and social systems (i.e., processes at the individual and at the group level), to analyze how each of these systems operates, and to comprehend how they influence each other.

Another key aspect of systems theories is *complexity*. Complex systems are dynamic systems that show a chaotic and nonlinear development. Thus, complex systems are systems with attributes that cannot entirely be explained through the attributes of the system's single parts, a phenomenon referred to as *emergence* (Johnson, 2001). Thus, the group of students in Roschelle and Teasley's (1995) aforementioned study can be regarded as a complex social system consisting of the communication of individuals who are related to each other and interact. The resulting collaborative understanding happens suddenly and perhaps unexpectedly. Similarly, the magic moments as described by Stahl (2006) cannot be determined beforehand.

Our own approach is based on a sociologically coined systems theory that was developed to describe various functionally different subsystems of societies, such as the economic system, the political system, and the legal system (Luhmann, 1995). Its starting point is the *distinction between cognitive and social systems*. Both cognitive systems and social systems are autopoietic, complex, and adaptive, but they fundamentally differ in their modes of operation (Luhmann, 1990, 1995, 2006). Cognitive systems are defined by thinking, that is, they create themselves in the processes of reasoning, making meaning, remembering, solving problems, and so on. It is a self-organized process where one thought builds on previous thoughts. Social systems create themselves through communication, which is also an autopoietic process. A social system only exists through communication which must always refer back to previous communication (Luhmann, 1990).

Cognitive systems and social systems both strive for meaning. That is, they try to make sense out of their experiences in order to build expectations about future issues and to be able to better adapt to their environment. So both kinds of systems are sensitive to information from their environments. But their different modes of operation (thinking vs. communication) preclude a direct transfer of information from one system to another. Individual thoughts cannot directly be incorporated into a social system; they must be verbalized, put into words, and communicated. Individual thoughts can only have an impact on a social system when transmitted through communication.

Communication, in turn, does not simply consist of a series of individual cognitive expressions. Communication requires that others understand utterances in the intended way. Therefore, communication is always based on reciprocal expectations (Bratman, 1992), common ground (H. H. Clark, 1996), and generally accepted conversational principles (Grice, 1991). Communication is more than the mere externalization of thoughts. To be understood correctly and to be influential in discourse, an individual has to consider what other people know, believe, and expect. For example, whether an expert discusses some issues with novices or with other experts will have an impact on how she expresses her thoughts. In that way, the social system implicitly defines what this person will verbalize. This example makes clear that individual cognitive systems cannot simply be considered to be lower level parts of a higher level social system; individuals are not just single components of a social system. For a group, the individuals represent its environment, and for the individuals, the group represents their environment.

An individual and a group are two separate systems that consist of their own particular operations. But—despite this *operational* closedness—they are adaptive and open to their environments. That means that they are amenable to stimulation (i.e., novel information) from their environment (i.e., from other systems). But they can only deal with this stimulation in their own mode of operation. In doing so they assign sense and meaning to new information that was initially meaningless to the system. A cognitive system makes meaning based on previous cognitive processes; a social system makes meaning based on previous communication. A cognitive system can deal with communicated information only by translating it into its own processes of thinking, problem solving, decision making, or the like.

A social system also translates incoming information into its own mode of communication. Imagine, for example, a strongly committed group of people in an online forum that propagates the curative effect of nutrition for all kinds of diseases (see Kimmerle et al., 2013). If a physician pointed out that many diseases cannot be cured by a particular diet, that group would just not “believe” this message. Probably, the group would rather discuss counterarguments and refer to (alleged) cases where such healing happened. In this case, the contribution of the medical expert would probably not convince the group and might even have the opposite effect.

Thus, cognitive and social systems are both characterized by processes of self-organization (see next subsection) in terms of autopoiesis (i.e., self-creation and self-maintenance of systems; see Maturana & Varela, 1980), both have to handle complexity, and both make an effort to constitute meaning out of the information coming from their environments (Kimmerle, Moskaliuk, Cress, & Thiel, 2011). In selecting information from their environments, cognitive and social systems reduce the complexity (i.e., unpredictability) of the environment. But, at the same time, this

course of action helps them to increase the complexity within their own boundaries. Making meaning leads to the enhancement, enrichment, and revision of knowledge, which is an autopoietic act: For instance, humans can perceive only a particular range of colors and limited frequencies of sounds (even though other wavelengths of color and sound exist). This is a limitation in the first instance. But this same limitation enables a person to avoid an overload of the cognitive system and focus on those pieces of information that can be processed and used to learn and build complex structures. Analogously, social systems select what they operate on. In the example of the nutrition forum, it is apparent that the group's belief in the curative effect of a particular type of nutrition is a way of dealing with complexity. To maintain its own process of making meaning, this group will take up only some of the arguments offered, whereas others will not be considered. These examples illustrate that both cognitive and social systems themselves determine what they consider to be meaningful. In this way, systems produce and re-produce meaning, that is, make sense of incoming information according to their own particular mode of operation.

The differentiation between cognitive and social systems helps to understand the relationship between individual and collective processes of handling complexity and constituting meaning when people interact with social media. In the following we therefore elaborate on the processes of (a) self-organization, (b) externalization and internalization, and (c) the interplay of externalization and internalization.

The Principle of Self-Organization

As explained earlier, complex systems are self-organized. Regarding cognitive systems this has been described in detail in constructivist approaches (see Piaget, 1977; von Foerster, 2003; von Glasersfeld, 1989), which argue that a cognitive system does not only process "input" information coming from its environment passively. The perception of information is instead an active construction process, based on an individual's prior understanding. Cognitive systems maintain themselves by continuing their own operations, where one train of thought is followed by another train of thought. Cognitive systems are autopoietic in that they build adaptable structures that allow connectivity to their own previous and subsequent operations.

Social systems are similarly self-organized. Social systems, too, do not merely process incoming information in a passive way. Communication always refers to an existing background of prior communication. This previous communication has left a net of interindividual relationships, expectations, and norms, which are the basis for all further activities that take place within the social system. This is what makes these systems autopoietic and self-organized. It is the communication itself that creates further communication (Luhmann, 1995).

Such processes of self-organization have been described, for example, in the context of communities of practice (Lave & Wenger, 1991). These are communities that emerge when people with a common concern or a common interest participate in shared practices (Kirschner & Lai, 2007; Lave & Wenger, 1991; Wenger & Snyder, 2002). These systems then develop a structure that shapes the further development of newcomers who, for instance, start from *legitimate peripheral participation* (Lave & Wenger, 1991) and later may become knowledgeable and influential members central to the community. It is the community itself that decides the roles, positions, and impact of its members.

Within these communities, knowledge communication and knowledge transfer take place, and *rules* and *roles*, which guide the communication processes, develop (Kimmerle et al., 2013). Communities of self-organized systems develop their structure over time in an autopoietic process. These rules and regulations, norms, and role structures may then provide orientation for accepted behavior. As a consequence, self-organized social systems are liable to a constant process of evolution.

Internalization and Externalization as Enablers of System Development

There is a long and prolific tradition of theories that posit learning as internalization of information (Piaget, 1977), in particular information originating from the social environment (Vygotsky, 1978). Cognitive systems do not internalize information by simply transferring and integrating it. On the contrary, internalization is an active process of *accommodation* and *assimilation*, that is, a permanent equilibration between the perceived external stimuli and the internal cognitive structures (Piaget, 1970, 1977). When people interact with others, they also internalize information by assimilation and accommodation (Kimmerle, Cress, & Held, 2010; Moskaliuk et al., 2011). As a result, their own cognitive structures evolve dynamically, which is regarded as a process of learning.

For individuals to learn from communication, others must have externalized their own knowledge beforehand. But, analogous to internalization, this externalization is not a mere transfer of information from a cognitive to a social system. Externalization is an equilibration process as well. Reasonable communication requires that people take the social system's mode of operation into account and follow the rules, norms, and goals of the community. The physician in the nutrition forum example will have an impact only if she takes the needs and beliefs of this specific audience into account. This means she has to adapt her message to the contents, norms, and rules that are relevant in this particular forum. Thus, it is the community that shapes her externalizations. It also means that information processing within each system tends to be conservative and self-reifying. Change and development may occur, however, if

FIGURE 1 The dynamic processes of learning and knowledge construction.

externalizations from one system trigger the development of another system. For this purpose, the externalizations need to provide an optimal level of conflict (see next). Knowledge construction is comprehensible only within the given social context and in consideration of the concrete activities of a community. Figure 1 summarizes the basic ideas of our approach.

In Figure 1 the social and the cognitive systems are both visually represented by closed circles. The cognitive system operates through cognition, whereas the social system operates through communication. These internal dynamic processes constitute each of the systems. For each system, the other one is part of its environment. The systems stimulate each other's development through processes of internalization and externalization. Externalized information (whether externalized by the cognitive or the social system) can be internalized by the other system. This changes the structure of the latter, which we consider as learning (individual system) or knowledge construction (social system). Each of these processes is represented in Figure 1 by arrows that show the dynamic development of the systems over time. Internalization and externalization are not meant as pure information transfer. Rather, the information is adapted to the operation mode of the respective system. So in the context of social media, individual learning is the result of the self-organization of a cognitive system that is confronted with new information while participating in a community. This cognitive system then applies its own mode of operation to this new information and tries to make meaning out of it. In this way, the cognitive system evolves by adapting its own structures to the information from its

social environment. Collective knowledge construction is the result of the self-organization of a social system that is confronted with new information when its members externalize their thoughts and knowledge. Analogously, the social system takes up the information from the cognitive systems that form its environment by applying the mode of communication. This in turn results in an adaptive evolution of the social system in terms of assimilation and accommodation. In the next section we describe in more detail what the mutual influence of cognitive and social systems looks like and how systems may develop dynamically and not just preserve the status quo.

Interplay of Externalization and Internalization

Externalization and internalization are the two main ingredients of individual learning and collective knowledge construction with social media. The question that occurs at this point is how their interplay is triggered. We assume that *incongruity* between an individual's knowledge and the information available within a shared digital artifact provided by social media motivates individuals to participate in the exchange of knowledge. As previously pointed out, Piaget introduced the concept of cognitive equilibration. His theory assumes that people experience cognitive conflict when they perceive information imbalances (in terms of incongruities). Their need for equilibration makes people rebalance their cognitive structures, which can be achieved by assimilating new information or by restructuring existing knowledge, which enables novel insights or even the revision of existing beliefs. Piaget's outlook was indeed systemic, but his focus was on the cognitive system—he was

solely interested in the internalization of information into an individual's cognitive schemata. Combining Piaget's notions with Luhmanns (1995) systems theory, however, allows for examining how social media enable concurrent development of individual and collective knowledge. The concept of cognitive conflict has an equivalent in systems theory. In Luhmann's terms, a cognitive conflict is an "irritation." Systems are irritated (i.e., stimulated) by new information from their environment, which do not meet their expectations. For example, if the nutrition forum receives the conflicting information that nutrition cannot cure all diseases, it has to deal with this information. It may accommodate and change its previous beliefs, or it may assimilate the new information, for instance, by questioning its validity or denying its relevance. Such processes happen only when new information causes a conflict. If new information is fully congruent with the previous knowledge and beliefs of a system, there is no need for adaptation, and thus development will not occur. But if new information is too different and contradicts previous knowledge and beliefs, the system will presumably ignore or reject it. We expect that there is an optimal level of incongruity that leads to activation and development (see also Berlyne, 1960; Hunt, 1965).

In other words, novel information from the outside stimulates individuals to think about it and social systems to communicate about it. From this point of view, learning and knowledge construction depend on the overlap of a user's own individual knowledge with the information discussed in a social system (Cress & Kimmerle, 2008). If the social system communicates information an individual does not know yet, there is opportunity for individual learning (i.e., internalization into the cognitive system). If, in contrast, the individual possesses information that is not contained in the shared digital artifact of a social media platform, knowledge construction can take place by means of the individual's externalizing the information. Typically, the community as a whole may not easily change its knowledge and beliefs when an individual utters a different perspective. However, it may sometimes be observed that a single author introduces a new aspect, which then influences the following contributions. For example, Cress and Kimmerle (2008) observed in the Wikipedia article about AIDS how an author introduced a new, quite deviating theory about the causes of AIDS, then the significance of the theory was extenuated by others, and finally it was integrated into the text and held its ground among other theories.

A continuous exchange between the systems leads to a *structural coupling* (Luhmann, 1995) of a cognitive and a social system. This coupling allows the two systems to benefit from each other, in that they stimulate each other through providing information that induces conflict. This allows them to learn from one another and to develop conjointly. In the course of this shared development, they mutually and continually make use of each other as resources. Accordingly, the resulting

development of the two systems can be characterized as *co-evolution*¹ (Cress & Kimmerle, 2008). The physician in the nutrition forum example provides information that is incongruent to what is being discussed in the forum. So this contribution may irritate the forum community, and the community's reactions may irritate the expert. Co-evolution does not necessarily mean that the knowledge and beliefs of both systems will become more similar over time, they may develop in different directions through their interaction (see Figure 1). The process of co-evolution just means that two systems influence each other's dynamics of change over time. We are far from being able to predict how systems will evolve under specific conditions. However, we have identified several important influencing factors that predict whether systems influence each other and whether their mutual impact triggers assimilation or accommodation processes. The following section gives an overview of such factors and some empirical evidence for their potency.

EMPIRICAL SUPPORT FOR THE PROCESS-ORIENTED PERSPECTIVE

So far we have described the processes underlying individual learning and collective knowledge construction from a systemic-constructivist point of view. We have identified self-organization, externalization, internalization, and the interplay of externalization and internalization as relevant processes. In addition, we have underlined some key aspects that are essential for these processes (i.e., rules, roles, incongruity between cognitive and social systems, assimilation, accommodation, and the co-evolution of cognitive and social systems). In this section we present empirical studies that support this process-oriented perspective. In doing so, we examine those key aspects and their impact on the processes. The systemic approach that we are proposing points out the relevance of self-organization and co-evolution in many different settings. It contributes to identifying these processes in social media settings as they occur in the field, but it also allows for investigating these processes in more detail by conducting experiments in the laboratory in order to test influencing factors and determinants.

We do not allege that our perspective is the only one that provides an explanation for the following findings. Other theories might possibly provide an explanation for some of the results we report. But at the very least, applying a systemic perspective as we do here provides a *coherent framework* for all of these different processes.

¹In biology, the term co-evolution does not refer to changing individuals in a changing environment but to changing species in relation to other changing species in the same environment. But the general principle of a mutual influence on each other's development is the equivalent to our approach.

Self-Organization in the Social System

The community of Wikipedia editors is a working example of self-organization. Wikipedia's current structure (e.g., its rules and role structure) has been developed over time by the community itself (again: an autopoietic process). Wikipedia editors decide themselves in what way they want to contribute to the encyclopedia. At the same time, the rules and role structures that provide "guide rails" for accepted behavior have evolved within the community (Butler, Joyce, & Pike, 2008; Forte & Bruckmann, 2006; Kittur, Suh, Pendleton, & Chi, 2007). The content of Wikipedia is subject to a continuous process of evolution, in which the community rewrites articles, links them with each other, deletes inappropriate entries, and discusses these activities on talk pages. Only those contents that meet the system's criteria, such as verifiability, for example, will remain available in the end (so this social system maintains its own meaning making by producing and re-producing its content in an autopoietic process as just described). What is particularly relevant for understanding the momentousness of self-organization is that in communities such as Wikipedia, even those stipulated standards themselves are, in turn, open for inspection, established and developed further by the community.

Oeberst et al. (2014) analyzed the self-organization in a social system in terms of the *rules* that were developed within the Wikipedia community. This study used for analysis the German Wikipedia article on the nuclear power plant of Fukushima in the first 9 days after a tsunami had caused a nuclear disaster (on March 11, 2011). During this time, the world was flooded with information of differing quality and certainty, and led several hundred Wikipedia users to integrate information into the article (see also Keegan, Gergle, & Contractor, 2011). The study illustrated the relevance of the community's self-developed rules for guiding self-directed individual contributions and thus the impact of this self-organization on the development of the article. Contributions that did not conform to Wikipedia's neutral point of view rule,² for instance, were either deleted within minutes by the community or changed in a way to make them conform. So this social system did not at all process incoming information by simply incorporating it in a one-to-one transfer. Rather, it adjusted the information to its own mode of operation. Beyond such an implicit application of community rules, the community was also very active in explicitly discussing adherence to the rules and norms on the article's talk page. This communication always referred to an existing background of prior communication. This meta-discussion about the content, its development, and appropriate application of rules appeared to be

essential for successful self-organization in this social system. Eventually, more than 1,000 contributions (i.e., revisions) were observed within these 9 days. Even though only a small number of contributions remained in the article, many of them presented aspects that influenced later contributions. The contributions helped to specify the general Wikipedia norms and to apply them to this particular case. In sum, this led to an article not only of remarkable length but also of high quality, as was attested by nuclear safety experts, despite the fact that the contributors were not domain experts and would have been incapable of writing such an article individually (Oeberst et al., 2014). The social system's self-developed rules, such as the rules of objectivity, neutral point of view, and others, are continuously discussed and applied in the Wikipedia community (see also Kittur et al., 2007), and their application facilitate the success of this collective endeavor. In other words, we might conclude that the regulatory functions of the social system were so meaningful and dominant that the attributes of the individual contributors were largely irrelevant. For example, it was not important whether a person had much domain expertise. Applying the rules of Wikipedia even enabled domain novices to identify the most relevant credible sources and pieces of information and integrate the respective information into the article. So knowledge construction in this social system occurred as an emergent process with characteristics that could not simply be traced back to the characteristics of the community members. In terms of systems theory, the manifestation of the higher level social system cannot simply be attributed to the characteristics of its lower level components.

What has also been observed in Wikipedia is the relevance of the different *roles* that the people involved assume, for example, substantive experts, technical editors, vandal fighters, or social networkers (Welser et al., 2011). Joyce, Pike, and Butler (2013) analyzed decisions of the Wikipedia community regarding articles proposed for deletion. They described bureaucratic structures as a system of roles and rules, on one hand, and individual agency as conflicting mechanisms, on the other: "Being an administrator, for instance, does not give a participant's expression of opinion greater power" (p. 590). This "hybrid deliberative bureaucracy" of Wikipedia is based on the active participation of the users and leads to a self-organized structure of the collaboration with a variety of different policies, procedures, roles, and rules (Butler et al., 2008).

In the online forum of a health-related outsider community, Kimmerle et al. (2013) found a role structure that had a strong impact on collective knowledge construction and the development of the community. Here, the communication was strongly geared to one particular user who answered most of the questions (in particular in cases of doubt), intervened in other users' discussions and rebuked them, and had the final say in virtually all issues. It was found that this role

²Wikipedia requires that all of its content is written from a neutral point of view, that is, all relevant views need to be represented "fairly, proportionately, and, as far as possible, without bias" (http://en.wikipedia.org/wiki/Wikipedia:Neutral_point_of_view).

structure kept the online forum operating. Accordingly, this analysis demonstrated how the particular structural characteristics of a social system were instrumental for the process of self-organization in terms of community formation and autopoietic community maintenance.

Triggers and Moderators of Externalization

In a laboratory experiment Moskaliuk, Kimmerle, and Cress (2009) manipulated the *incongruity* between prior knowledge of an individual and the information presented in a wiki about the causes of schizophrenia. Participants were asked to contribute to a wiki text based on prior knowledge that had been acquired within the experiment. Prior knowledge was held constantly high (information about both biological and social causes for the formation of schizophrenia), whereas the information available in the wiki text was varied: It included no relevant information (high level of incongruity between individual knowledge and information in the wiki), half of the information individuals already possessed (i.e., only biological or only social reasons; medium level of incongruity), or all relevant pieces of information (biological and social reasons; low incongruity). This experimental procedure allowed for examining how much individual prior knowledge had been externalized into the wiki. Accordingly, this course of action also allowed for examining to what extent externalization of an individual's knowledge from the cognitive system into the social system had an impact on individual learning. The medium level of incongruity between prior knowledge in the cognitive systems and information contained in the wiki as a social system resulted in a higher quality of collective knowledge construction (*accommodation* in the social system) and in more individual learning (*assimilation* and *accommodation* in the cognitive systems). As the opportunity to internalize information from the wiki was held constant in all conditions, the results clearly revealed the influence of externalization on both individual learning and collective knowledge construction. As just outlined, a certain level of incongruity appears to be a prerequisite for triggering conflicts that stimulate advancement of knowledge in both cognitive and social systems.

To examine two separate facets of incongruity, Moskaliuk, Kimmerle, and Cress (2012) in an additional experiment analyzed the redundancy and polarity between people's prior knowledge (cognitive systems) and the information in a wiki text (social system). They found that a medium level of redundancy between prior knowledge and information in the wiki text stimulated learners to integrate new arguments into the article, and in this way facilitated the development of the text. Polarity, in contrast, contributed to the quality of the text by motivating learners to integrate contradicting arguments from their prior knowledge into the shared wiki text.

Triggers and Moderators of Internalization

In another laboratory experiment with wikis, Kimmerle, Moskaliuk, and Cress (2011) varied the amount of people's prior knowledge but held the information in the wiki text constantly high across all conditions. Because all relevant information was already included in the wiki in all conditions (and thus all participants had access to the identical information), this procedure particularly allowed for examining internalization of information and the impact of internalization on knowledge construction: Again, the research question was whether the *incongruity* between prior knowledge of an individual and the information presented in a wiki influenced learning and knowledge construction. The results showed that the amount of individual learning merely depended on the amount of prior knowledge induced before using the wiki. But, consistent with our theoretical considerations, the results also showed that a medium level of incongruity led, once again, to a higher quality of knowledge construction (*accommodation* in the social system) compared to low and high incongruity.

In self-organized social systems *rules* and *roles* develop over time. However, the question occurs as to how people make use of information from a community when no rules and roles are available yet in a community, like in a laboratory experiment. If rules and roles are important for individual learning, but remain unclear in a given situation, then people are bound to look for other indications of social preferences. Indeed, based on self-categorization theory (Turner, 1987), a study by Matschke, Moskaliuk, and Kimmerle (2013) identified people's group membership (see Tanis & Postmes, 2003) as a moderator that has an impact on individual learning in social contexts. This experiment showed that users integrated information into their cognitive systems to a different extent depending on whether the information originated from members of the in-group or from the out-group. This effect held true even though group membership was completely irrelevant for the knowledge domain (here: being a soccer fan in the realm of a medical topic): When users believed that information came from members of the in-group they internalized more information than when they thought that the information had been provided by the out-group (see also Mackie, Worth, & Asuncion, 1990). That is, even though the roles of other group members as soccer fans were totally unrelated to the actual topic, people acknowledged and were influenced by this social information and, as a consequence, internalization and learning were strongly affected by these roles. Similar findings were reported by Bientzle, Cress, and Kimmerle (2013) in an experimental field study: Physiotherapy students acquired more factual knowledge from a shared digital artifact when the information in the artifact was consistent with the opinion of their own group. So students did not just confirm their biases, they also acquired more knowledge when the information came from a group that shared their opinions. These results

specify how learning with social media is influenced by social information about the community and social identification with the community.

Several studies show that social tagging tools implicitly link individual learning to collective knowledge-related processes in that individuals—without any guidance or social structure and just by browsing—internalize knowledge from the social system (Kimmerle, Cress, Held, & Moskaliuk, 2010). Through tag clouds that result from the collective folksonomy, users implicitly inherit an overview of concepts that other users associated with a particular search term. When people make use of tag clouds as searching devices, they have the opportunity to become aware of relevant keywords annotated by other users. Several experiments clearly showed that during their Internet search, users experienced incongruities between their own conceptual knowledge and that visualized in the tag clouds, which made them internalize the conceptual structure provided by the tag cloud (Cress, Held, & Kimmerle, 2013; Held et al., 2012). Thus, participants expanded their own knowledge, understood when their own associations with a topic were incorrect, and even changed their cognitive concepts accordingly.

Interplay of Externalization and Internalization

Empirical evidence for the viability of the co-evolution perspective comes from a field study with Wikipedia data. This study found empirical evidence for the *co-evolution* of cognitive and social systems. Using social network analysis as a visualization technique, Kimmerle, Moskaliuk, Harrer, and Cress (2010) compared the development of Wikipedia articles about one topic with the individual development of the authors who contributed to these articles (for visualization of Wikipedia data, see also Brandes & Lerner, 2008; Viégas, Wattenberg, & Dave, 2004). They analyzed all articles that were linked to the article about schizophrenia. On the collective level, they used the link structure of all relevant articles to infer pertinent subtopics. This procedure identified three clusters of articles (reflecting psychoanalytical theories, biological factors, and social aspects). The authors measured how these clusters merged or increased their density over time and found that the psychoanalytical cluster remained isolated, whereas the biological and social clusters had merged into a new cluster (representing an integrated model). This revealed a dynamic development representing the conceptual understanding of schizophrenia in the Wikipedia community. This structure resulted from the collective action of numerous users over years.

On the individual level, the researchers analyzed the articles that each of the single users had coauthored. They found a similar development of the artifact network and the authors' work. The analysis of the authors, in contrast to the collective level, reflected only the articles each author had edited—without considering any of the other authors. It showed that people who had previously worked on articles

about psychoanalysis did not change their subject (i.e., they stuck to psychoanalytical articles), whereas people who had worked on biological or social aspects started to work on articles from the respective other topic (i.e., “biological” authors began to coauthor social topics, and vice versa). By comparing the dynamical development of clusters in the article network (collective level) to the development of the contributions by the authors (individual level), these findings show a co-evolution of cognitive systems and the social system.

In another study using Wikipedia as a data source, Halatchliyski et al. (2014) found evidence for the particular relevance of *roles* in collective knowledge construction. They considered all articles belonging to two adjoined knowledge domains (psychology and education). Using network analysis (see Wassermann & Faust, 1994), they distinguished between central articles within one of the article networks (each presenting one domain) and central articles that served as boundary spanners between the two distinct networks. Based on the Wikipedia classification of articles and authors' previous contributions, Halatchliyski et al. (2014; see also Halatchliyski & Cress, 2014) defined expert knowledge and identified whether authors had assumed the role of specialists (with specialized experience in a single domain) or that of generalists (with generalized experience in both domains). They found that specialists mainly contributed to central articles within that particular domain, whereas generalists mostly contributed to boundary-crossing articles between the two knowledge domains. Methodologically speaking, the measures of centrality and boundary spanning resulted from the *emergent* link structure of articles,³ not just from the a-priori categorization. What is particularly interesting is that a role that develops out of experience in different knowledge domains seems to be an important precondition for being able to make helpful contributions to interdisciplinary knowledge construction.

DISCUSSION

The article presented here was divided into three parts. At the outset, we reviewed literature on the use of social media for educational purposes. We criticized that many studies fall short of considering social media in the context of their original designation for informal settings with potentially large groups of users. Instead, social media were frequently thrust into situations in which their tools were used for learning and knowledge exchange in formal curricular, externally guided settings. We proposed in the second part of this article a framework that identifies relevant processes

³Note that these measures arose from the analysis of the overall network. So the data on the community level referred to a holistic structure that cannot be reduced to the particular contributions of the specialists and generalists. In other words, analyzing this type of structural coupling requires a nonreductionist method.

of individual learning and collective knowledge construction which are enabled by social media, namely, self-organization, externalization, internalization, and the interplay of externalization and internalization. These processes also explain how cognitive and social systems handle complexity and adapt to their respective environment in terms of a mutual development of knowledge. We also pointed out several aspects that are relevant in these processes: rules, roles, incongruity between cognitive and social systems, assimilation, accommodation, and co-evolution of systems. In the third part, we presented research findings from lab and field studies that have taken those aspects into consideration when it comes to supporting learning and knowledge construction. We claim that identifying underlying processes of individual learning and collective knowledge construction along with influential factors is a relevant starting point for future research about the potential of social media for educational purposes.

In this context, we emphasize that our goal is not to provide an entirely new approach to education. What we can and want to do, however, is to make researchers and educators more aware of how individual learning and collective knowledge construction result from self-organized and operationally closed systems. What teachers want students to do is one thing, but it is another thing to recognize how and which norms and rules develop in the social system of a class or course. From a systemic perspective, the learners and the group are at the center of attention, not educational requirements such as learning targets, grades, or curricula. Such requirements come from outside. They do not *directly* influence students' behavior; they only represent irritations (i.e., stimulations). External requirements irritate the cognitive and the social systems that are involved in education, but it depends on the systems' modes of operation how these external factors stimulate a particular behavior. Accordingly, from this perspective, shaping education means to think about how stimulation can be designed in order to make cognitive or social systems operate on the issues that educators want them to operate on.

Formal uses of social media are constrained. But even so, we point out that when educators try to use social media in formal contexts, the same processes can take place that we have described for informal settings. So our approach does not suggest distinguishing between formal or informal settings but states that also in formal settings, communication and cognition occur as self-organized and operationally closed systems. We propose that the full potential of social media will be realized only when a community is created that leads learners to get actively involved in collective knowledge construction. This will happen if the community itself creates a norm that will motivate users to externalize their knowledge in such a way that others can build on it. That one's own knowledge might be taken up and used by others may then be a motivating factor for learners. It has been pointed out that learners in collaborating groups

usually enjoy the interaction with others and the autonomy they have in deciding what they want to contribute (Chinn & Clark, 2013; Rogat, Linnenbrink-Garcia, & DiDonato, 2013). The group should not only focus on knowledge exchange but also create a common goal resulting in a common endeavor where learners can feel a sense of belonging. This sense of belonging can accompany the principle of epistemic agency as expressed in the knowledge-building approach (Chan, 2013; Scardamalia, 2002). Learners who appreciate their community may be more willing to bring their individual ideas in line with those of others and to collectively modify them.

Social media should not just be implemented in a class as tools for curricular learning. Instead, social media need to be recognized and used as the central catalysts of activities in self-organized communities. A spirit of collaboration will be able to evolve in the classroom only if a class uses such tools to develop goals collectively with all individuals involved. In the following we hint at some implications for educational design, and we suggest potential next research steps and open questions that might be answered based on the process-oriented perspective.

With regard to *self-organization*, a relevant question is how norms and rules might be stimulated that explicitly emphasize the common goal of collectively sampling arguments and improving ideas in order to develop community knowledge. Collaboration settings and contexts might be designed in such a way, for example, that they allow for examining how information about the group and its members has an impact on norm development and self-organization in social systems. This might be done, for example, by providing the opportunity to access detailed social media user profiles or browse through the timelines of the users (for the role of group awareness in computer-supported collaborative learning and knowledge construction, see also Cress & Kimmerle, 2013). Others have also claimed that future learning technologies need to be attuned to the qualities of self-organizing systems (Scardamalia & Bereiter, 2014).

Another worthwhile research endeavor for educational psychologists could be to study how to stimulate social systems in ways that support the related communication processes that allow individuals to interact with others, autonomously externalize their knowledge, and contribute to collective idea improvement. *Externalization* of one's own knowledge in a way that makes it connectable to information in a social system can improve both learners' content knowledge and their argumentation skills. Further research could examine how communication in a social system interacts with other factors that potentially influence externalization, such as the learning setting, the instruction given, or the behavior of the teacher. How to find valid measurement of these processes and ways to analyze how they mutually influence each other are further questions that have to be examined.

Analogous to questions about externalization, the main question about *internalization* is how to stimulate a social system in such a way that individual learning is supported in a group. A promising next step would be to focus on the variables of the social system that motivate individuals to integrate new information into their existing cognitive structures. Some examples of these variables might be the availability of information about the roles of other members of the group, the structure of the shared digital artifact, or the given tasks or rules in the social system. The main challenge of using social media in educational settings is to implement more implicit or incidental ways to foster intrinsic motivation and autonomy and trigger individual learning in terms of both assimilation and accommodation. From a methodological point of view, the question arises about how to distinguish between variance that is due to communication and variance due to cognitive processes.

This methodical question also applies to the *interplay* of externalization and internalization. A central claim of our research perspective is the suggestion that researchers and educational practitioners should consider social and cognitive processes in tandem in order to understand and support individual learning and collective knowledge construction. Educational settings as well as research designs in this context should therefore consist of variables that address both systems simultaneously. For this purpose, future research needs to further analyze how internalization and externalization influence each other. In particular, it appears to be worthwhile to examine exactly what the character of incongruity between cognitive and social systems needs to be in order to facilitate assimilation and accommodation in both systems. This claim also highlights the relevance of methodological pluralism that expands existing methods to measure both learning and knowledge construction in educational research and practice.

On the whole, educators need to keep the processes of self-organization, externalization, internalization, and co-evolution in mind and constantly come up with ideas about how to support them even in constricted formal educational settings. Moreover, future research in educational psychology can make an important contribution to a better understanding of individual learning and collective knowledge construction with social media. Corresponding research findings may suggest to researchers and practitioners how to support these processes more productively. In this way, such research can make a significant contribution to the successful application of social media in educational contexts.

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