
Moving beyond scientific knowledge: leveraging participation, relevance, and interconnectedness for climate education

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Abstract: Climate change requires a massive global response: individuals, communities, regions, and nations all need to make substantial change to current habits and behaviours. Education is an important part of changing habit and behaviour, yet most contemporary climate change education focuses primarily on individual's knowledge about climate science, which research suggests has limited utility in supporting collective response to climate change. This article proposes a new focus on educational intervention that is sensitive to the shared need for rapid, collective impact. Drawing on socio-cultural learning theory and a review of research on climate change learning, we argue that interventions based on three core principles – participation, relevance, interconnectedness – are more likely to result in people taking steps to respond to climate change than interventions based on knowledge acquisition alone.

Keywords: climate education; climate change learning; limitations of climate knowledge acquisition; informal learning; participation for climate education; relevance for climate education; interconnectedness; collective efficacy; collective impact; socio-cultural learning; collective response to climate change.

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1 Introduction

Climate change influences and is influenced by economic, ecological, and political systems at global, national, and local levels. Although people may be gradually becoming more aware of the need to reduce their environmental impact and to respond to climate change, progress is far from sufficient: expanded and immediate institutional, societal, and community changes are necessary to address the effects of current global climate change (Intergovernmental Panel on Climate Change, 2013; Sun et al., 2010). Climate change education for children and adults, both in and out of school, is a part of ramping up a response to climate change, but prior efforts have been scattered and uncoordinated (Abbasi, 2006; Choi et al., 2010; National Science Board of the US, 2009).

A common assumption underlying many educational interventions is that people fail to act in response to climate change because they do not understand climate science (Barr, 2007; Grotzer and Lincoln, 2007; Moxnes and Saysel, 2009; Nigbur et al., 2010; Shepardson et al., 2009, Sterman and Sweeney, 2007). The science of climate change is vast and complicated, covering topics such as the greenhouse gas effect, processes and impacts of sea level rise, increases in extreme weather events, changes in precipitation patterns, and resultant changes in habitat composition (Intergovernmental Panel on Climate Change, 2013). Researchers and educators have explored the best ways to teach climate science and address common misconceptions among both children and adults (e.g., Shepardson et al., 2009; Taber and Taylor, 2009). And they have had success: Although much climate science is difficult to learn, even the more complex topics can be effectively taught under certain conditions (Cordero et al., 2008; Moxnes and Saysel, 2009; Shepardson et al., 2009; Sterman and Sweeney, 2007; Taber and Taylor, 2009).

However, even when people know about climate science, there is little direct evidence that knowledge, or the gaining of it, leads to behaviour change. The assumption that decisions are based on scientific knowledge has been described as an oversimplification of how people make choices (van Kerhoff and Lebel, 2006; Zia and Todd, 2010), and psychology researchers have demonstrated that scientific understanding is not what determines people's actions or opinions with regard to climate change (Kahan et al., 2012).

The authors assert that increasing climate science knowledge is not a sufficient outcome for climate education if it is to be leveraged to address the problem of climate change. To contrast with traditional 'knowledge only' climate education, in this article *effective* climate change learning is defined as that which enables responses to climate change that are commensurate with the scale of the problem and appropriate for communities' unique needs and situations. The primary way climate education efforts can do this is by increasing collective efficacy. Collective efficacy is the sense that one's actions, in combination with the actions of one's community and those with whom values are shared, have the capacity to make the desired impact. Responses commensurate with the scale of climate change are enacted at the level of communities and governance systems, and collective efficacy is a requisite for engaging with these systems.

The primary goals of this article are:

- 1 to consider the evidence that knowledge about climate change is not sufficient for action
- 2 to argue that educational interventions should focus on increasing collective efficacy for responding to climate change
- 3 to introduce three learning science principles for effective climate change learning.

In pursuit of these goals, the authors used a systematic methodology for reviewing and synthesising a very large set of adjacent literatures. The process began with a focused review of recently published learning sciences literature concerning informal learning, design-based research, and the relation between learning and action. This review identified a set of three principles that are hypothesised to support effective learning about complex socio-scientific issues. The authors then used these three principles to guide a broad review of literature in climate change education, climate change psychology, and climate change communication, looking for extant educational approaches that might be informed and extended by application of learning sciences concepts.

2 From knowledge to collective efficacy: new goals for climate education

It may seem obvious that, in order to address the challenges of global climate change, people must be well informed about the issue. It may then also follow that the more people know about the causes and consequences of climate change, the more likely they will be to change their behaviour to mitigate or adapt to climate change. However, knowledge of the phenomenon turns out not to predictably result in individuals making choices that are 'scientifically informed' or 'environmentally friendly' (Kahan et al., 2012; Pidgeon and Fischhoff, 2011; Shepherd and Kay, 2012; van Kerhoff and Lebel, 2006). So, if knowledge is not sufficient to change behaviours and decision-making, what is?

Understanding what actually influences human behaviour and decision-making in response to climate change is a difficult research goal. One problem is that knowledge acquisition is relatively easy to measure after an intervention (e.g., with a test), while behaviour change may occur well after learners have left the intervention context and returned to their lives. Thus, many researchers have approached the question of behaviour change by measuring attitudes as a proxy for behaviour (Cordero et al., 2008; Devine-Wright et al., 2004; Taber and Taylor, 2009; Aguilar and Krasny, 2011; Ranney et al., 2012). One study suggested that climate change knowledge had some influence on attitude (Ranney et al., 2012), and several have shown that attitudes can be too sensitive to knowledge-based intervention (Aguilar and Krasny, 2011; Cordero et al., 2008; Taber and Taylor, 2009). However, there is evidence from other research domains that attitudes about an issue do not accurately predict real-life decision-making unless the choice being made is relatively low-cost (Boyes et al., 2009; Diekmann and Preisendorfer, 2003). In other words, increasing people's knowledge, even if that knowledge has some impact on their attitudes, may not be sufficient for influencing their behaviour with regard to climate change.

The most convincing evidence that knowledge of climate science alone does not impact people's behaviour comes from the work of Kahan et al. (2012). They found that even among people who are highly knowledgeable about the science of climate change, opinions about what can or should be done are polarised along ideological divides. They attribute this pattern to the powerful influence of individuals' identity groups: the communities on which they are most dependent for social and physical resources (Kahan et al., 2012). That is to say, people's collective identities have a much stronger influence on their behaviours and beliefs about climate change than their scientific knowledge, which can work for or against the goals of educational intervention (Hart and Nisbet, 2011; Hobson and Niemeyer, 2012; Nigbur et al., 2010). To effectively learn to respond to climate change, people are forced to deal with several interconnected factors outside their scientific knowledge, particularly emotions and collective identities (Bain et al., 2012; Devine-Wright et al., 2004; O'Neill and Nicholson-Cole, 2009; Patchen, 2010; Roeser, 2012; van Kerhoff and Lebel, 2006). Therefore, climate education must take into account the emotions and collective identities upon which people depend to inform their decision-making. The importance of these factors on climate change learning and the argument for focusing climate change education on increasing collective efficacy follows.

Emotions are an important influence on learning in general (Linnenbrink, 2007; Pekrun and Linnenbrink-Garcia, 2010), and on learning about climate change especially, since it is an emotionally and politically charged topic (Lombardi and Sinatra, 2013; Roeser, 2012). In the case of climate change, emotions can actually impact people's ability to make useful assessments of available information (Lombardi and Sinatra, 2013; Lombardi et al., 2013; Sinatra et al., 2012). For example, teachers who expressed anger towards the topic of climate change had more difficulty accurately assessing climate change information (Lombardi and Sinatra, 2013). A similar relationship between emotions and ability to accurately assess climate change information was found among undergraduate college students (Sinatra et al., 2012). What these survey and test results illuminate is the high level of influence that emotions can have over what has often been assumed a separate, rational system of thinking.

Emotions are also a powerful influence on how people respond to information about climate change. For example, the counterproductive effect of prevalent 'doom and gloom' messages about climate change has been widely documented (Feinberg and Willer, 2011; Grotzer and Lincoln, 2007; O'Neill and Nicholson-Cole, 2009). Dire messages and tragic imagery, such as lonesome polar bears trapped on shrinking ice floes, tend to demotivate and promote disengagement from the issue, and in some cases can even decrease people's belief that climate change is a problem at all (Feinberg and Willer, 2011). For learners who are working to apply new knowledge in real-life contexts, information that evokes dread, fear, or guilt must be accompanied by clear options for action (Feinberg and Willer, 2011; Grotzer and Lincoln, 2007; O'Neill and Nicholson-Cole, 2009; Wolf and Moser, 2011).

Climate change must be addressed by people at the collective level. Socio-cultural learning theories provide a framework for understanding how learning itself is a shared process that taps into people's collective identities (Greeno, 2006; Lave and Wenger, 1991; Wenger, 1998). Collective identity is a set of values or beliefs that are empowering to those who identify with and share them (Jamison, 2010). One particularly pertinent form of collective identity is ideology, an important set of values by which people assert and connect to their communities. The importance of ideology on people's opinions

about and responses to climate change has been widely documented (Bain et al., 2012; Borick and Rabe, 2010; Feygina et al., 2010; Hart and Nisbet, 2011; Lewandowsky et al., 2012b; Shepherd and Kay, 2012; Zia and Todd, 2010). And, as we have noted, it is the determining factor in how highly knowledgeable people decide what can and should be done to respond to climate change (Kahan et al., 2012). Not only that, ideology strongly influences which information sources people are likely to trust (Terwel et al., 2010; Zia and Todd, 2010). This means that ideology as a form of collective identity can have a strong impact on whether or not people perceive there to be scientific consensus regarding the seriousness and urgency of climate change, which has also been shown to be an important influence on how people respond to climate change (Ding et al., 2011; Lewandowsky et al., 2012a).

The authors assert that the most important feature of learning to invoke effective responses to climate change is the promotion of collective efficacy. Whether or not people possess factual knowledge about climate change does not make any difference if they lack collective efficacy (Leiserowitz et al., 2012; Van Zomeren et al., 2010). People who are knowledgeable about climate science and what they can do in response may fail to act because they know individual actions make no significant impact in mitigating or adapting to global climate change (Kahan et al., 2012; Roeser, 2012).

Collective efficacy encompasses people's emotions, knowledge, and identity as they relate to their community, all of which have been demonstrated to be important predictors of and influences on climate-friendly behaviour (Almers, 2013; Van Zomeren et al., 2010; Whitmarsh and O'Neill, 2010). If people feel like their communities can be effective in responding to climate change, then they will be empowered to respond collectively at a scale commensurate with the problem and appropriate to communities' unique needs and situations. What follows are several examples and three principles for effective climate change learning that have demonstrated success in increasing collective efficacy in educational interventions.

3 Collective efficacy as an outcome of climate education: three principles for effective climate change learning

Recognising that interventions focused mostly on changing knowledge have not yielded significant changes in how people respond to climate change, several examples of educational interventions that resulted in behavioural changes are used to introduce three principles for effective climate change learning. The authors posit that the difference between traditional intervention and these examples is the increase in participants' collective efficacy, which empowered them to change behaviours.

Two examples of increased collective efficacy through climate change learning come from research on the professional development of educators. Ongoing, facilitated, and reflective conversation about climate change as a professional development activity has been effective for both classroom teachers and informal educators (e.g., museum educators). These ongoing interventions influence how educators approach climate change content in their practice (Allen and Crowley, 2014) and their everyday actions (Pruneau et al., 2006). In the first case, museum educators in Pittsburgh, USA engaged in a two-year project to develop new field trips about climate change. These educators were active participants in the process of making climate change relevant to their students (and

themselves). The climate change content became more relevant as educators saw how it was interconnected with the museum exhibits about which they were experts and their students' learning experiences (Allen and Crowley, 2014). In the second example, a group of teachers in Canada volunteered to make changes in their everyday lives that would have environmental benefit. They met every three months over the course of one school year for professional development on climate change education, to create climate change education models for their classrooms, and discuss and reflect on their efforts in changing their own personal behaviours that impacted the environment (Pruneau et al., 2006).

In both these examples, educators had opportunities to reflect together on their practice and actions that impact climate change. Connection to educators' professional communities was influential on their efficacy beliefs and motivation to respond to climate change (Allen and Crowley, 2014; Pruneau et al., 2006). This kind of conversation-based participation is particularly effective because it is relevant to educators' work, and enables understanding of the interconnected questions and issues in their professional practice, as well as individual and collective choices with regard to climate change. Both examples highlighted long-term engagement with professional development, creating opportunities for interconnected learning experiences that simultaneously allowed educators to see how climate change is interconnected with other aspects of personal, social, and civic life. Educators from both studies reported that the most important part of their experience was the sense of purpose and efficacy they derived from being part of a network of professionals with whom they identified and participated – in other words, these professional development experiences increased collective efficacy (Allen and Crowley, 2014; Pruneau et al., 2006).

Urban planning researchers have documented another example of increased collective efficacy through self-directed watershed management projects that affected participants' local neighbourhoods in Portland, Oregon, USA. Community organisations partnered with urban planning advisors and Portland's public works department to design and implement the projects, which lasted anywhere from one season to several years. The urban planning advisors found that involvement increased when participants felt they had real ownership from the beginning (Shandas and Messer, 2008). Ongoing participation in relevant projects led people to see how their actions and environment were interconnected. Researchers documented increased awareness of local environmental issues, an enhanced network of community partners, and tangible results in improving watershed quality; all of which helped to give participants a sense that their work contributed to real improvement – an increased sense of collective efficacy. When participants were empowered to identify the problems, goals, and processes they would address and use, projects were ensured to be relevant and have maximum success. Projects like this incorporate learning and doing. The combination of action, networked expertise, and opportunities to experience real, tangible results in a community setting increased collective efficacy for participants because they were active participants in their own learning and doing (Shandas and Messer, 2008).

By examining the above examples in combination with further learning science and climate change education research, the authors identified three principles for climate change learning that increases collective efficacy: *participation*, *relevance*, and *interconnectedness*. They are described in detail and followed with an examination of how they might play out in practice. These principles should be tested, examined, and refined in ongoing climate change learning interventions.

Participation. Participation in activities and conversations in communities with whom individuals identify is an important way to enrich collective efficacy, identity, and sense of responsibility (e.g., Allen and Crowley, 2014; Devine-Wright et al., 2004; McCrum et al., 2009; Pruneau et al., 2006). Participation also supports learning and changes in behaviour and decision-making (Eberbach and Crowley 2009; Leinhardt et al., 2002; Palmquist and Crowley 2007). Since there is not a singular ‘silver bullet’ solution to climate change, people need to participate in ongoing processes of understanding and addressing it (Tschakert and Dietrich, 2010; Walker et al., 2004). Although people tend to avoid new information that challenges their world-view or way of life (Dickinson, 2009; Feygina et al., 2010; Shepherd and Kay, 2012) participation in meaningful, relevantly framed group activities and conversations can broaden people’s world views and support imagining a way of life that takes climate change into consideration (e.g., Terwel et al., 2010). For climate change learning, participation means interaction with other learners and facilitators, in conversation, deliberation, and activities, which may be models or simulations (e.g., Snyder et al., 2014), or real-life actions (e.g., Shandas and Messer, 2008). Participation with members of one’s community is an essential step toward increasing collective efficacy.

Open-minded discussions and critical evaluation of evidence promote conceptual change (Lombardi and Sinatra, 2013; Sinatra et al., 2012), and are important ways for communities to address and grapple with the cognitively and emotionally interconnected issues that come with facing difficult challenges (Cameron et al., 2013; Devine-Wright et al., 2004; Moser, 2010; Pruneau et al., 2006; Van Zomeren et al., 2010). Participating in well-facilitated conversations increases collective efficacy by building trust among community members and between constituents and decision makers (Terwel et al., 2010).

Participation for climate change learning can involve all kinds of interaction and can take place in diverse venues. For example, deliberative workshops use conversation among participants and presenters, interactive presentations, and debates among experts and stakeholders, and can additionally reinforce community identity (Hobson and Niemeyer, 2012; McCrum et al., 2009). Museums create interactive, participatory exhibits where learners can manipulate models of climate impacts on watersheds, and urban infrastructure (Snyder et al., 2014). Museums can also serve as community hubs for conversation and deliberation (Cameron et al., 2013). Local governments in partnership with conservation organisations and educational organisations can provide opportunities to participate in projects that have real outcomes for participants’ communities (Shandas and Messer, 2008).

Relevance. Necessary for learners, individually and in their communities, relevance allows people to see why they should care and how they can make meaningful choices based on new experiences and information. Research on behavioural change has identified relevance as an important feature of learning that has an impact on behaviour, especially in the specific case of climate change (e.g., Akerlof et al., 2013; Bain et al., 2012; Joireman et al., 2010). Relevance is communicated through framing, or the way information is positioned in terms of learners’ prior experiences and knowledge. Framing is examined in both education research and in the study of social movements, where participants have opportunities to both learn about and engage (often politically) around a relevant issue. Researchers of social movements have found that “the framing of a condition, happening, or sequence of events as unjust, inexcusable, or immoral is not sufficient to predict the direction and nature of collective action” [Snow and Benford,

(1992) p.137]. This has often been the case with efforts to educate about and communicate climate change, when frames fail to communicate the relevance of an issue; the result is disengagement (Feinberg and Willer, 2011; Grotzer and Lincoln, 2007; O'Neill and Nicholson-Cole, 2009).

For framing to be most relevant, it should address the direct and local experiences that people have, because direct experience buffers outside (i.e., media) agendas (Akerlof et al., 2013; Shome and Marx, 2009). Since ideological views influence how communities respond to climate change, frames should be customised to make climate change information relevant to those communities. For example, in more conservative communities, environmentally friendly behaviour is much more relevant and satisfying when framed as an issue of economic or energy security, or an act of patriotism, such as buying goods made in the USA (Bain et al., 2012; Shome and Marx, 2009). If learners are unable to identify how information or an experience is relevant to their lives, they are unlikely to be motivated to seek further understanding or make changes based on new information or experiences. Similarly, communities and groups of learners must be able to see how information and experiences are relevant to their lives and what they consider important – collective efficacy cannot increase based on irrelevant information.

In order for educational interventions to be relevant to communities, designers of such interventions must take into consideration the extant knowledge, expertise, and interests of the communities with which they wish to engage. Engagement with communities should involve community members and leaders identifying what aspects of climate change impacts are most relevant to them. Educators and organisers of programs about climate change can benefit from seeking the insight of their audiences and participants about what is most relevant in a particular community.

Interconnectedness. A single learning event is unlikely to have a lasting impact; however, interconnected learning experiences and engagement that are relevant to learners have been demonstrated to be effective for climate change learning (e.g., Allen and Crowley, 2014; McCrum et al., 2009; Pruneau et al., 2006; Shandas and Messer, 2008). Not only that, but climate change itself is better understood as interconnected with the biological and social systems people interact with regularly, rather than as an isolated phenomenon (Lombardi and Sinatra, 2013; Sinatra et al., 2012). Education researchers who study student conceptions of climate change recommend that curricula present climate change from a “systems-based perspective rather than in isolated segments” (Shepardson et al., 2009) in order for students to see the interconnected features of climate change. If communities can perceive how economic, infrastructural, and political systems are also interconnected with the impacts of climate change, they will be better equipped to engage with those systems to respond to climate change impacts at a broader level. Systems thinking enables learners to improve understanding of both the parts and the interconnections that make up systems, imagine future outcomes and behaviours, and think creatively about how to engage with systems (Meadows, 1997). Unfortunately, systems thinking is not generally recognised as a strong attribute in most highly educated adults (Houser, 2009). On the other hand, participation in relevant learning experiences that are connected to one another can help learners to better engage in systems thinking and build understanding of how climate change impacts multiple aspects of their communities. Interconnected learning experiences across multiple contexts can promote community-level learning and adaptation (Ito et al., 2013).

By incorporating participation, relevance, and interconnectedness into climate change education, learners' collective efficacy and their understanding of how to respond to

climate change in ways that are commensurate with the scale of the problem will be more possible when compared with educational efforts with the single aim of increasing climate science knowledge. Increasing collective efficacy requires that learners experience the real impact of their efforts. People identify with those around them, and make decisions based on implicit social norms within their communities (e.g., Nigbur et al., 2010). Identity and social norms are consistently predictive of climate friendly behaviours (Whitmarsh and O'Neill, 2010), while knowledge and values are more likely to influence behaviour when normative pressures are lower (Barr, 2007; Nigbur et al., 2010).

How might designers of educational interventions implement the principles for effective climate change learning? A critical starting place will be to harness the energy and momentum of existing community resources and programs that already have established participants (e.g., Snyder et al., 2014). Tapping into existing networks of action, education, and community development is likely to be one reliable strategy for engaging communities that already have social relationships and shared understanding of what is relevant to them. It is essential that educators and organisers are aware that the communities they hope to educate are experts on their own lives, needs, and surroundings. Working with and engaging communities, rather than imposing interventions 'on' them, can reveal appropriate frames for understanding and conversations that naturally connect to the systems with which people already engage on a regular basis (Collins and Ison, 2009).

For example, the authors are part of a large-scale effort to incorporate participation, relevance, and interconnectedness into climate change education programs that are implemented through diverse networks of organisations in four US cities (Snyder et al., 2014). In each city, informal education organisations, climate scientists, and learning scientists are networking with community organisations that represent neighbourhoods, local environmental efforts, and special interest and affinity groups. Each of these networks is developing a city-specific set of messages, activities, and engagement opportunities that are tailored around current issues and identities in the city. Thus, rather than delivering a top-down message about climate change, the work is embedded in the bottom-up interests of the city and thus reach audiences (and organisational partners) who may not identify with climate change as an issue. Through this ongoing climate change education project, the authors are currently engaged in testing, refining, and better understanding the usefulness of the three principles for effective climate change learning. This work is primarily being conducted through qualitative, observational analysis of the networks' engagement with one another and with their audiences, and how they implement participation, relevance, and interconnectedness in the climate education materials and programs they are creating and refining.

4 Conclusions

In order to take advantage of the impact and influence that collective identities and communities have on how people react to climate change, educational interventions should move beyond the goal of simply increasing people's scientific knowledge about climate change. Many who are knowledgeable about climate change and what needs to be done to respond have low collective efficacy: even though they know what needs to

happen, they do not feel strongly that enough other people will take the same necessary steps (Leiserowitz et al., 2012). Increased collective efficacy is a necessary condition for learning to respond to climate change in ways that are commensurate with the scale of the problem and appropriate for communities' unique needs and situations. This article introduced three principles for effective climate change learning by way of increased collective efficacy: participation, relevance, and interconnectedness. Research has demonstrated that learning experiences that incorporate these principles facilitate not only knowledge acquisition, which is not sufficient for effective responses to climate change (Kahan et al., 2012) but also increase collective efficacy (e.g., Allen and Crowley, 2014; Pruneau et al., 2006; Shandas and Messer, 2008). Further testing of the utility and impact of these three principles for effective climate change learning would help to refine and clarify how these principles can be utilised to promote responses to climate change in communities.

Although individuals and their local and professional communities can take steps to adapt to and mitigate climate change, policy level changes are needed for larger scale adaptation, at the level of cities and countries (e.g., Filho, 2010; Steffen, 2011; Sun et al., 2010). Governments harden cities against flooding, shift energy production to renewable sources, distribute water, and regulate emission standards (Jaeger, 2004). Therefore, in order to respond to climate change in a way that is commensurate with the scale of the problem, people need to work together at the level of policy, toward large-scale changes that address the national and international systems of commerce, energy, and consumption that enable and contribute to the heat-trapping gases that cause climate change.

Collective efficacy is necessary for engagement in political processes. Since climate change is a shared, global problem, political solutions cannot be left out (Jaeger, 2004). However, policy changes in response to it have been difficult to enact, particularly in the USA (Collins and Ison, 2009; Steffen, 2011). The largest causes of carbon emissions are the result of industrial and infrastructural systems that can only be indirectly affected by individuals through participation in political systems and processes, with which people are unlikely to engage if they do not feel their efforts will have impact. Paralleling collective efficacy, trust among community members and decision-makers is an important predictor of engagement in public governance processes (Terwel et al., 2010). Climate change educators and organisers face a major challenge in the ambiguous nature of responsibility for climate change. Many individuals do not feel empowered or responsible to take action on climate, because it is perceived as a distant, global, governmental, or industry-based problem (Moser, 2010; Patchen, 2010). By participating in relevant, interconnected learning and actions, communities will enhance their collective efficacy and capacity to respond to climate change at the scale commensurate with the problem and appropriate to each community' unique needs and situation. Participation can help people feel more efficacious in their responses to climate change; relevant frames can provide the motivation to participate and engage in understanding climate change in one's own community; and the interconnected nature of these phenomena and the experiences learners have will push our communities to be more engaged at all levels.

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