CLIMATE CHANGE CONTROVERSIES IN THE MATHEMATICS CLASSROOM

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In this paper, we investigate the challenges teachers expressed in relation to the inclusion in mathematic classrooms of politically controversial topics like climate change. Based on critical mathematics education, we consider mathematics education to be political and not neutral. Data from two empirical studies, an online survey and a research partnership, were analysed. We found that some teachers saw maintaining neutrality as a challenge, that curriculum allowed little room for controversies, and that they found it difficult to deal with students' opinions and their lack of motivation. However, some stressed the importance of a pedagogy for hope, motivating students to take a stance and to act. We suggest that researchers take an active role by including controversies in the education of mathematics teachers.

INTRODUCTION

"Global warming is a total, and very expensive, hoax!" (Trump, 2013) and "No challenge poses a greater threat to future generations than climate change" (Obama, 2015). The first quote is Donald Trump's tweet from 2013, the second is Barack Obama's tweet from 2015, and these two quotes illustrate different poles of opinion in the climate change debate. Climate change is one of society's most complex challenges for several reasons: it involves physical science, economics, ethics, and political aspects. Levin, Cashore, Bernstein, and Auld (2012) referred to climate change as a super wicked problem, and identified four unique features related to such problems: time is running out; those seeking to solve the problem are also those causing it; there is no central authority; and present policies discount the future irrationally. Barwell (2013) argued that mathematics is crucial to understand, to describe, to predict and to communicate about climate change, and that mathematics education needs to be involved. He suggested that ideas from critical mathematics education are relevant when considering how teaching and learning can engage with issues of climate change.

Climate change controversies entail scientific, social and political aspects. In this paper, we understand political controversy as Hess (2009) defined it; an issue that spark significant disagreement. Hess argued that schools need to face controversies, and raised the important question of what determines whether a topic is a controversy. Depending on context, she defined a tipping point at which a topic move from being a controversial issue to a settled case (and vice versa). There is scientific consensus that climate change exists, and we see this as a settled case. However, there are many political controversies connected to climate change, related to such issues as the effects of climate change, what should be done about it, and who should bear the burden. Therefore, we consider the issues of climate change to be (potential) political controversies. In these disagreements, arguments cased on mathematics are often used.

For instance, when Trump announced the withdrawal from the Paris Agreement, he argued that China should contribute more because they are the world leader in emissions. Measured in absolute values in 2016, China has 10.4 Gt CO_2e (no. 1) while USA has 5 Gt CO_2e (no. 2). However, measured per capita, China has 8.5 t CO_2e (no. 36) and USA has 20 t CO_2e (no. 14) (Knoema, n.d.). These two different perspectives (absolute values vs per capita) illustrate how numbers can be employed strategically, and challenge the idea that numbers are non-political. Mathematics researchers such as Atweh (2012), Ernest (2009), Mellin-Olsen (1987), Skovsmose (1994) emphasized that mathematics is not objective, value-free or non-political. Public debates about climate change can be based on biased use of mathematics; for example, in the selective use of graphs by interest-organizations. Steffensen, Herheim, and Rangnes (2018, p. 1) stressed that, if citizens view such mathematics as neutral and value-free, they "could be exposed to a political standpoint without being aware of it".

The Norwegian Education Act (1998) emphasized that students "shall learn to think critically and act ethically and with environmental awareness". The general part of the curricula emphasized that climate change is one of the greatest environmental threats globally, and stressed that subjects should facilitated students in gaining insight into, and critically reflecting on, the challenges and dilemmas related to climate change (Ministry of Education and Research, 2017). Although several researchers in mathematics education argue for including controversies in the classroom, and have described some of the challenges this involves for teachers (e.g. Gutstein & Peterson, 2005), few have investigated teachers' perspectives related to including climate change in mathematics education. In this paper, we draw upon data from two empirical studies to investigate the question: *What challenges do teachers express related to the inclusion of political controversies about climate change when teaching mathematics*. The purpose of this paper is to reveal challenges and, by doing so, to develop knowledge about what can support in- and pre-service teachers when including controversial topics like climate change in mathematics teaching.

THEORETHICAL PERSPECTIVE AND EARLIER RESEACH

Gutstein and Peterson (2005, p. 6) problematized the notion that it is possible to teach mathematics in a neutral manner. They exemplified this with a mathematical problem concerning multiplication, with two different context; one involving consumerism; the other including global awareness and empathy. They argued that teachers, who do not bring out the underlying implications of e.g. consumerism, or help students to confront the role of mathematic in the context of important global issues, are making a political choice "whether the teachers recognize them as such or not". However, Monroe, Plate, Oxarart, Bowers, and Chaves (2017, p. 2) stress that many teachers think "their job is limited to conveying factual information", while some facilitated critical thinking and address ethical considerations. Climate change controversies often arise from what is considered to be factual information, and public perceptions of mathematical models as an exact science that is driven by experts with correct answers can cause public dis-interest. Ernest (2009, p. 207) argued that "human interest and values plays a

significant part in the choices of mathematical problems, methods of solution, the concepts and notations constructed in the process". An absolutist views on mathematics could facilitate an antidemocratic exploitation; for instance, through careful use of mathematical data by politicians or interest organizations. Ernest claimed, therefore, that a socially responsible mathematics education should create an awareness of this in schooling. Similarly, Steffensen et al. (2018) argued that climate change could serve as a powerful topic to teach citizens to recognize interest-driven use of mathematics.

Simic-Muller, Fernandes, and Felton-Koestler (2015) stressed and problematized the fact that the real-life contexts implemented in policy documents and teaching tend to be "neutral" topics such as shopping. Furthermore, their research indicated that pre-service teachers were less willing to teach controversial topics than other real-life contexts, and that, when the teachers talk about real-life tasks, they "equate real-world contexts with any contextualized or story problems", e.g. pizza cutting (2015, p. 69). Hess (2009) emphasized some barriers blocking the inclusion of controversies in school, including the fear of indoctrination of students into a particular political viewpoint. Hess and McAvoy (2014) raised the issue that many Americans dispute the fact that climate change exists, and although there is a strong consensus in the scientific community, many teachers choose to teach climate change as a controversy, not as a settled case. Furthermore, Hess (2009) found that teachers used different approaches teaching controversial topics, such as denial, avoidance, and balance, as well as privileging of a particular perspective. For instance, a balanced approach would be if teachers' deal with the existence of climate change as if there were two equally valid sides; and an avoidance approach would be to exclude the topic. Several studies, as reported by Hess (2009), found that many teachers avoid controversial topics and do not confront political interests and values. Similarly, Atweh and Brady (2009) reported "resistance by many mathematics teachers and curricula developers to deal with controversial social issues as a source of examples of mathematical problems" (p. 271). They further argued for a "willingness to deal with controversial topics in which debate and difference of opinion and interests are part of the equation rather than nuisance variables" (p. 272). Furthermore, Atweh (2012) emphasized that mathematics education should shift towards an ethical and responsible approach, including changes in the curriculum, and more problem solving, modelling and real-world activities. Similarly, Jurdak (2018, p. 30) argued for changes because present curriculum could "constrain the ability to interrupt inequality because of its structure and orientation", and suggested that curriculum should facilitate the learning of mathematics in rich social contexts.

Abtahi, Gøtze, Steffensen, Hauge, and Barwell (2017) addressed the issue of how the inclusion of climate change in mathematics education can be a moral and ethical act. With regard to whether it is right to expose students for problems like climate change in the classroom, they argued that students already face these issues, and that the real question is whether they should deal with them alone or in dialogue with others. Similarly, Simic-Muller et al. (2015) reported that pre-service teachers believed that,

if they protected the students from difficult problems, they were teaching with care. A related issue was raised by Wals (2011), who problematized the way that education for sustainability could lead to a sense of hopelessness, which in turn could lead to paralysis. It was considered that such problems of great magnitude and complexity could easily overwhelm citizens. To address such hopelessness, Freire (1992) introduced a pedagogy for hope, arguing that practice should always be rooted in hope; otherwise, students could feel powerless in relation to the possibility for change.

Nicholls (2017) found that it is important to consider teachers' beliefs when teaching climate change because political views influenced decisions about inclusion/exclusion of topics in classrooms. Similarly, Steffensen et al. (2018) stressed how the controversies related to climate change and teachers' values could influence teaching. For example, two teachers designed different questions to emphasize certain issues; while one emphasized the increased rate at which Arctic ice was melting, the other stressed how small the rise in global temperature had been. Both teachers used mathematics to support their claims. Namdar (2018) found that when pre-service mathematics and science teachers included climate change in their teaching, they considered it a benefit that they could encourage students to act, raise awareness, increase content knowledge, and influence future decision-makers. The challenges they perceived included students' disinterest, teachers' preparedness, technical difficulties related to teaching, the controversial nature of the subject, and existing misconceptions. The above-mentioned research on controversies and climate change concerns mainly pre-service teachers. In this paper, we discuss findings related to the challenges raised by in-service teachers and these findings are linked to theory and previous research.

METHODS

The data for this paper was collected from two independent studies. The first was an online survey. This was conducted to gain insight into teachers' thoughts on teaching mathematics in the context of climate change, their aims, what they emphasised, and any challenges they experienced (see also Abtahi et al., 2017). The survey was posted in a Facebook group for mathematics teachers, and the total number of respondents was 72: with 15% at primary school level, 43% at lower-secondary school and 47% at upper-secondary school; some worked several places. All questions were voluntary, which meant that some questions had fewer than 72 respondents. Both closed and open questions were included, but in this paper only the answers to the open questions have been analysed. The second data was from a one-year research partnership with three mathematics and natural science teachers in lower secondary school. This was inspired by action research (see also Steffensen et al., 2018) and researched into how climate change could facilitate students' development of critical perspectives. A strategic sample was obtained based on previous knowledge of teachers' engagement in both climate change and mathematics. The data collected included video recordings of seven partnership meetings and 42 classroom interactions, audio recordings of interviews, written materials from teachers and students, and field notes.

In the analysis, utterances from the partnership meetings and answers to three survey questions provided the basis for answering the research question. The three questions where we identified challenges were: “What challenges do you experience when teaching climate change?” (Question 1 with 41 responders); “We would be grateful if you would elaborate on your thoughts on climate change in mathematics education” (Q2, 38); and “If you had sufficient resources, how would you like to work with climate change in teaching?” (Q3, 35). All data was transcribed, coded and categorized into themes by using NVIVO. Six central themes emerged from the data (number of utterances in parenthesis): No challenges (3), Content knowledge (25), Teaching resources (16), Practical issues (10), Objectivity (10), and Values (14). These were partly overlapping; for instance, utterances related to objectivity could also take up teaching resources. We excluded challenges of a more general nature and those with weak links to political controversies. For instance, although the number of utterances indicated that content knowledge was regarded as an important topic, the teachers did not connect this to the political controversy, and explicitly concerned teachers and students content knowledge. We then had four themes left: Teaching resources, Practical issues, Objectivity and Values. The utterances from the three teachers were matched with categories established for the online survey for consistency of perspectives. In the results and discussions section, we present various challenges included in the four themes that structure the text. We have chosen to analyze some representative utterances from each theme to exemplify these challenges.

RESULTS AND DISCUSSIONS

The theme *teaching resources* involved both those designed specifically for teaching (such as textbooks with tasks, ICT, and video) and those available in the media (such as web sites and news). An example of the former was an utterance from the survey in which the teacher problematized the types of task used in mathematics education: “Fewer tasks with "Per and Kari should pick strawberries" and more "Emissions of greenhouse gases makes up..."” (a respond to Q2). By comparing a task concerning greenhouse-emissions with one involving old-fashioned and typical Norwegian names like Per and Kari and a common Norwegian activity like picking strawberries, the teacher problematizes this rather indifferent semi-realistic reference and calls for a more meaningful real-life reference. Although both tasks refer to reality, there is an important difference between these two real-life contexts: while one context often simply exemplifies mathematics processes such as division and fractions, the other context can involve complex issues as well. For instance, the very nature of the greenhouse gases issue means that it has the potential for political controversy and, if students disagree with measures such as taxes on greenhouse-gases, this could spark disagreement in the mathematics classroom. This teacher’s problematization of the use of different real-life contexts was in contrast to the findings from Simic-Muller et al. (2015), where the pre-service teachers did not differentiate between the different contexts real-life task could have. Another teacher from the survey stated that it was a challenge to find “Good and up-to-date resources that are not political” (a respond to

Q1). This utterance calls for "non-political" resources, hence a more neutral perspective, and it is not recognized that, as research has revealed, neutral teaching of mathematics is impossible, including mathematical task and teaching resources (cf. Gutstein and Peterson, 2005; Simic-Muller et al., 2015).

The theme *practical issues* included challenges related to lack of time, available ICT and other resources, large classes, and the curricula. Here we focus on concerns related to curricula. The teachers from the research partnership found it challenging to balance the extensive list of competence aims in mathematics, the pressure to prepare students for exams, and the desire to include climate change in mathematics teaching. Teachers from the survey, gave following utterances: "Unfortunately, we must prioritize getting through the curriculum" (Q3) and "Do not expand subjects with topics not explicitly mentioned" (Q2). Thus, the teachers hesitated to expand subjects with topics not mentioned and prioritized in curricula, since these are less likely to be tested on exams. This can be interpreted as a conflict between their responsibility for student's grades and their desire to include important real-life problems. Subject curricula and competence aims guide the teacher's choice of problems in mathematics education and, if an absolutist view of mathematics has influenced the curricula (cf. Ernest, 2009), then the curricula may become an obstacle hindering the inclusion of important social issues, as the above mentioned utterances exemplified. A curriculum should not hinder the inclusion controversial socio-political problems (cf. Atweh, 2012; Jurdak, 2018), and changes are necessary so that curricula can provide space for teachers and students to engage in mathematics related to social problems. Although the teachers in the research partnership expressed concerns about including climate change and balancing competence aims and exams, they chose to do so by taking an interdisciplinary approach (cf. Atweh & Brady, 2009). Curricula changes take time and, if we think it is important to include controversial topics like climate change, then we have to find ways to support teachers in their efforts to balance between competence aims, interpreted, enacted and experienced curriculum; to prepare students for exams; to prepare students to be(come) engaged citizens capable of discussing real-life controversial topics.

The theme *objectivity* focused on how teachers' and students' political standpoints are perceived to be a challenge, and how the ideals of objectivity and neutrality are maintained. One teacher from the survey considered it a challenge to "be objective" (Q1). One way to interpret this is to be unbiased when presenting a topic or when choosing specific tasks (cf. Steffensen et al., 2018), another way can refer to not influencing (or indoctrinating) students (cf. Hess, 2009). Another teacher from the survey said that it was a challenge "to be neutral in the debate" (Q1). This teacher's concern about remaining neutral (not taking a part or supporting a position) in the climate change debate could indicate that their aim is to present themselves as neutral in classroom debates. A relevant question then becomes whether it is possible to teach climate change or mathematics in a neutral manner (cf. Gutstein & Peterson, 2005). A related utterance from the survey is: "There are many views in the climate debate. Teachers are not exceptions and I am one of them. If we are too eager to present our

own views, it will be easily mistaken" (Q2). This teacher recognizes that there are many views on climate change among teachers, and expressed the opinion that to present one's own views is challenging because it can be "mistaken" (it does not say whether by the students, their parents or the school administration). Underlying this utterance may be a fear of doing harm, thrusting opinions, or being forced into conflicts with students (or others) who disagree. It is safer to simply convey the factual information that many teachers see their job as being limited to (cf. Monroe et al., 2017). Presenting controversial topics and, in particular private views, can be challenging for teachers for fear of being accused of indoctrinating students with political viewpoints (cf. Hess, 2009). The teachers in the research partnership emphasized not only presenting factual knowledge, but also engaging students in critical thinking and ethical consideration of climate change through discussions and debates. In these teaching activities, students' opinions were facilitated and were recognized as a productive contribution to learning. Contrary to this recognition to students' opinions, some teachers considered it a challenge that students had opinions, as this utterance from the survey exemplifies: "Students have strong opinions from home or from their own "research" online" (Q1). The teacher recognized that students can hold "strong opinions", which they might have obtained from parents and/or from online resources. Why this is seen as a challenge, is not explained. If a student's contribution is not what the teacher considers appropriate, this could potentially give rise to political controversies in the classroom. To facilitate debates, critical discussions and that airing of different opinion (cf. Atweh & Brady, 2009), can challenge the understanding of mathematics education as neutral, objective and value free (cf. Ernest, 2009; Mellin-Olsen, 1987).

The theme *values* included teachers' concerns about motivation and engagement, as well as ethical considerations. One example related to teacher motivation is the following utterance from the survey: "This is an important area, but the teacher must be personally involved to prioritize it" (Q2). The teacher identified climate change as an important topic, but express that teachers have to be engaged at a personal level in order to make space for the topic. Given the demanding curriculum with no explicit competence aim on climate change, this highlights the teacher's role in bringing climate change into the mathematics classroom. Two utterances concerning student motivation were: "Some of the students care absolutely zero" (Q1), and "You hear too much about it and that nothing helps, it gets a bit weary" (Q1). The first utterance recognized that some students do not care about climate change. The wording "absolutely zero" stresses that this lack of engagement is perceived as a challenge for the teacher. The second utterance offered perceived reasons for students' apparent lack of motivation, namely too much focus, in combination with a feeling of helplessness (cf. Freire, 1992; Wals, 2010). The magnitude and complexity of climate change can easily overwhelm citizens and lead to paralysis. It seems to worry the teachers that students do not care, even though the topic is so serious and can potentially have a huge negative impact on our future. The teachers from the research partnership also expressed concern about student motivation, as one utterance exemplifies: "It does not really mean anything, 180 ppm [parts per million], oh well, yes, and then these girls

think, can we do our make up now?" The reference to 180 ppm illustrates an example of how students are indifferent to figures from climate change publications and, from the teacher perspective; do not mean anything to them. A second utterance picks up this theme: "Everyone agrees to do something about it, but they [students] don't do anything about it themselves". This expresses a concern that the students "don't do anything". The teachers from the research partnership discussed how they could motivate and engage students in climate change, and make them believe that individual action does indeed contribute. This utterance illustrates this:

> "And I think that in one way it is important that they make conscious choices, for instance with respect to consumption as we discussed. Somehow do something to stop climate change… and not just sit there playing PlayStation. So I think in a way it is important to also show that, if everyone contributes, it is actually possible to do something".

The teacher stressed two key actions here, "make conscious choices", and "do something", and emphasized how important it is that "everyone contributes". The focus is on providing students with hope that actions matter, hence a pedagogy of hope. Another challenge raised was allowing students to face the gravity of climate change. One teacher from the survey described it as a challenge "To explain the severity combined with the lack of action". The teacher does not explain why this was perceived as a challenge, but it could be interpreted as a reluctance to worry the students, and a desire to shelter them from a serious problem (cf. Simic-Muller et al., 2015). The weakness with this kind of argument is that students probably are already aware of the severity of the problem and the "lack of action", and then the question becomes whether they should face this without the guidance of teachers (cf. Abtahi et al., 2017).

CONCLUDING REMARKS

The challenges teachers identified in relation to including climate change controversies in the mathematics classroom were associated with teaching resources and practical issues, and they problematized the fact that the curriculum allowed little room for teaching complex issues. They considered the curricula to be their guidelines, and when controversial topics were not mentioned explicitly, some said that these would not be included in their teaching plans. Some described it as a challenge that students lacked motivation, while others problematized the fact that some students had already formed opinions outside school. In contrast, some teachers stressed that tasks connected to climate changes could be meaningful, and others that it was important to encourage students to take a stance, act and learn from experience that we all can do something. With regard to the objectivity, we found that this appeared within several themes (explicit and implicit), although with different perspectives. For instance, some teachers expressed concerns regarding teacher objectivity in the classroom and called for non-political teaching resources. We maintain, like Gutstein and Peterson (2005), that when mathematics teachers choose to strive for neutrality and objectivity in mathematics education, or choose to include/exclude controversial issues like climate change, this is already a political standpoint. Many of the challenges described by the in-service teachers in the online survey and research partnership are similar to those

pre-service teachers have highlighted in other research. This indicates the importance of an increased focus on raising the awareness of teachers, teacher educators and researchers regarding controversies such as climate change. Since teachers may consider an approach based on controversies and critical mathematics education to be very demanding, we suggest that a critical focus on this issue be implemented in teacher education. The aim of such an addition would be to give pre- and in-service teachers the opportunity to practice and gain experience in teaching controversial topics, and to cope with challenging issues such as ethical and objectivity concerns. Furthermore, more research is needed on controversies in the curricula, teaching resources and the question of how to implement controversy themes in classrooms.

REFERENCES

Abtahi, Y., Gøtze, P., Steffensen, L., Hauge, K. H., & Barwell, R. (2017). Teaching climate change in mathematics classroom: An ethical responsibility. *Philosophy of mathematics education journal*, *32*, 1-18.

Atweh, B. (2012). Mathematics education and democratic participation between the critical and the ethical: A socially response-able approach. In O. Skovsmose & B. Greer (Eds.), *Opening the Cage* (pp. 325-341). Rotterdam: Sense.

Atweh, B., & Brady, K. (2009). Socially Response-Able Mathematics Education: Implications of an Ethical Approach. *EURASIA Journal of Mathematics, Science & Technology Education, 5*(3), 267-276.

Barwell, R. (2013). The mathematical formatting of climate change: critical mathematics education and post-normal science. *Research in Mathematics Education, 15*(1), 1-16.

Education Act. (1998). Act of 17 July 1998 no. 61 relating to Primary and Secondary Education and Training (the Education Act) (LOV-1998-07-17-61).

Ernest, P. (2009). Values and the social responsibility of mathematics. In P. Ernest, B. Greer, B. Sriraman (Eds.), *Critical issues in mathematics education* (pp. 207-216. Charlotte, NC: Information Age Publishing.

Freire, P. (1992). *Pedagogy of hope.* Chippenham: Continuum Publishing Company.

Gutstein, E., & Peterson, B. (2005). *Rethinking Mathematics: Teaching Social Justice by the Numbers.* Milwaukee, WI: Rethinking Schools.

Hess, D. E. (2009). *Controversy in the Classroom: The Democratic Power of Discussion*. New York: Routledge.

Hess, D. E., & McAvoy, P. (2014). *The Political Classroom: Evidence and Ethics in Democratic Education*. New York: Routledge.

Jurdak, M. (2018). Integrating the Sociocultural and the Sociopolitical in Mathematics Education. In M. Jurdak & R. Vithal (Eds.), *Sociopolitical Dimensions of Mathematics Education* (pp. 15-33). Cham, Switzerland: Springer.

Ministry of Education and Research. (2017). *Verdier og prinsipper for grunnopplæringen - overordnet del av læreplanverket* [Values and principles for primary and secondary education]. Retrieved from https://www.regjeringen.no

Knoema. (n.d.). World Data Atlas: CO_2 emissions. Retrieved from https://knoema.com/atlas/ranks/CO2-emissions and https://knoema.com/atlas/ranks/CO2-emissions-per-capita

Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2012). Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. *Policy Sciences*, *45*(2), 123-152.

Mellin-Olsen, S. (1987). *The Politics of Mathematics Education*. Dordrecht: Reidel.

Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2017). Identifying effective climate change education strategies: a systematic review of the research. *Environmental Education Research*, 1-22.

Namdar, B. (2018). Teaching global climate change to pre-service middle school teachers through inquiry activities. *Research in Science & Technological Education*, 1-23. DOI:10.1080/02635143.2017.1420643

Nicholls, J. (2017). Queensland teachers and climate change education. *Curriculum Perspectives*, *37*(1), 79-82. DOI:10.1007/s41297-017-0016-8

Obama, B. (2015, Januar 20). No challenge poses a greater threat to future generations than climate change." President Obama #SOTU #ActOnClimate [Tweet]. Retrieved from: https://twitter.com/barackobama/status/557733214576705536

Simic-Muller, K., Fernandes, A., & Felton-Koestler, M. D. (2015). "I Just Wouldn't Want to Get as Deep Into It": Preservice Teachers' Beliefs about the Role of Controversial Topics in Mathematics Education. *Journal of Urban Mathematics Education*, *8*(2), 53-86.

Skovsmose, O. (1994). *Towards a Philosophy of Critical Mathematics Education*. Dordrecht: Springer.

Steffensen, L., Herheim, R., & Rangnes, T. E. (2018). Wicked problems in school mathematics. In E. Bergqvist, M. Österholm, C. Granberg, & L. Sumpter (Eds.), *Proceedings of the 42nd Conference of the International Group for the Psychology of Mathematics Education* (Vol. 4, pp. 227-234). Umeå, Sweden: PME.

Trump, D (2013, December 6). Ice storm rolls from Texas to Tennessee – I'm in Los Angeles and it's freezing. Global warming is a total, and very expensive, hoax! [Tweet]. Retrieved from: https://twitter.com/realDonaldTrump/status/408977616926830592

Wals, A. E. (2011). Learning Our Way to Sustainability. *Journal of Education for Sustainable Development*, *5*(2), 177-186.