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Designing creative inter-disciplinary science and art interventions in schools: The case of Write a Science Opera (WASO)

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Abstract: The goal of this qualitative study is to provide theoretical knowledge and design principles for a creative educational environment characterized by simultaneous study and exploration of science or math, and the arts: Write a Science Opera (WASO). To do so, we used a theory of creativity in education which links collaborative co-creation in creative activity, and identity: Wise Humanizing Creativity (WHC). Data were collected from teachers in interventions during which the WASO environment was implemented in two Norwegian primary schools. The topics of study were the multiplication table at the first school, and temperature at the second. Data relating to these participants' experiences and perceptions were coded and analyzed in order to articulate the kind of creative activity witnessed. The data, which consisted of interviews and reflective notes, were analyzed based on Educational Design Research (EDR) theory in order to explore design principles which could enrich WASO in the future, as well as to provide theoretical knowledge to other educational researchers.

ABOUT THE AUTHORS

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PUBLIC INTEREST STATEMENT

This study provides theoretical and practical knowledge regarding Write a Science Opera (WASO), a creative educational environment characterized by simultaneous study and exploration of science and art in primary schools. By collecting and then analyzing qualitative data from participating in-service and pre-service teachers, the study characterized the kind of creativity identified during WASO. Implications for how WASO may be designed in the future as a consequence of that characterization are detailed and contextualized within current trends in educational policy with regard to creativity in schools.

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> I believe we succeeded in offering pupils a creative approach to research about temperature, as they got the chance to employ the scientific theme on several levels. Pupils had to think about characteristics of various (scientific) elements, so as to be able to communicate to the audience which elements they are representing. Isabel, WASO Pre-Service Teacher

1. Introduction

The Norwegian Government recognizes the importance of creativity for the school of the future (NOU 2015: 8, 2015). The ability of pupils to explore the curriculum creatively is seen to have social, cultural and financial value (NOU 2015: 8, 2015, p. 22). Providing pupils with educational environments that enable creativity is thus a priority. On the EU level, there is determination to increase creative activity in education (European Ambassadors' Manifesto of the European Year on Innovation and Creativity, 2009; European Commission, 2007). This determination has recently given rise to several European creative education initiatives (e.g. Craft et al., 2016; European Commission Erasmus+, 2017). According to Sawyer (2012), creativity combines approaches of the humanities and sciences as it is inherently "interdisciplinary", and is a "borderline" field of research (p. 284). The current study focuses on articulating creativity in the context of Write a Science Opera (WASO), a creative educational environment which relies simultaneously on both science[1] and art education within a common framework (Craft et al., 2016). Little has been written about creative educational environments characterized by cross-disciplinary art and science exploration from a perspective of Education Design Research (McKenney & Reeves, 2012). This study therefore fills a gap by producing new knowledge regarding the WASO design. To do so, the authors observed WASO as an exemplification of Wise Humanizing Creativity (WHC) theory, which was originally developed for, and supported empirically by, educational contexts. Our analysis is based on two iterations[2] of WASO in Norwegian primary schools.

1.1. WASO

WASO is an inter-disciplinary creative educational environment in which art and science educational practices take place simultaneously and in dialog with each other. To this end, pupils of different ages simulate the creation of an opera-company in which they assume all responsibilities, including management and administration. They are supported by teachers (in-service and/or pre-service) and external opera (composers, visual artists, drama specialists) and science teachers. The goal is an educational school-opera process and performance based on a scientific theme (Ben-Horin, 2014; Craft et al., 2016). WASO is an application of the widespread Write an Opera method[3] (Royal Opera House, 2012) which allows for all pupils to take on all roles in a simulated "opera company" regardless of their previous arts-education training.

In the current study, undertaken in 2014–2015, WASO iterations lasted between two and three weeks. During that period, pupils and their teachers focused almost exclusively on WASO. During both iterations, pre-service teachers (PSTs) worked alongside in-service teachers, as part of the PSTs' obligatory practicum training.[4] During both iterations, curriculum science or math themes were introduced to pupils for the first time through the creation of a school opera. The topic for the first iteration (the multiplication table) was chosen by the school's head teacher. The topic for the second iteration (temperature) was chosen during discussion between Author 1, the external teachers, and two of the teachers at the school. PSTs had these teaching responsibilities: science/math, arts and crafts, music, drama, and public engagement.

2. The research question

What characterizes creativity in the WASO context? What do such characteristics imply for the design of WASO as a creative learning environment?

3. Theoretical framework

There is no single definitive history of creativity or of its inter-relationship with research (Albert & Runco, 1999, p. 16). We focus, therefore, on recent research that leads towards our chosen area within the field of education.

People are at their most creative during peak experiences known as *flow* (Csikszentmihaly, 1990). These experiences were first described as including intensity of awareness, absorption, heightened consciousness, and an obliviousness to the environment and to the passage of time (May, 1959; as quoted in Sawyer, 2012, p. 78). Of particular relevance for the current study is the notion of *group flow* (Sawyer, 2012, p. 244–246). During group flow, groups are performing at their maximum effectiveness as an "improvising team (which) creates a novel, emergent product … more suitable to the problem than any one team member could have developed alone" (p. 245).

Banaji, Burn and Buckingham (2010) reviewed existing creativity theories from the perspective of regarding them as rhetorics of creativity. These were the creative genius; democratic and political creativity; ubiquitous creativity; creativity for social good; creativity as economic imperative; play and creativity; creativity and cognition; creative affordances of technology; and the creative classroom (p. 70–71). The current study's research focus resonates with more than one of these rhetorics,[5] and especially with the "creative classroom" and "ubiquitous creativity." The "creative classroom" rhetoric relates directly to the arena in which the studied WASO iterations took place (classrooms). This rhetoric argues for the place of creativity in an otherwise increasingly monitored and regulated curriculum, something which corresponded to our impressions when approaching schools in order to obtain permission to implement WASO. "Ubiquitous creativity," which is closely related to *everyday* creativity, lies at the heart of the educational approach in WASO: Pupils' successful participation in WASO (whether as orchestra musicians, actors/performers, stage designers, etc.) does not depend on their having any prior knowledge or experience within those fields. "Ubiquitous creativity" is furthermore not limited to the arts (Chappell, 2008, p. 3), and is therefore representative of a crucial perspective in the inter-disciplinary WASO environment.

Creativity in the field of education has been defined as "the process of having original ideas which have value" (Robinson, 2012). There is some consensus among creativity researchers that creativity is domain-specific, while some consider it to be a generic phenomenon (Sawyer, 2012, p. 392). When understood as a domain-specific phenomenon, creativity is based on extensive study and mastery of a set of cognitive structures related to that domain. Our framework must therefore consider the arts, science, and the intersection between them.

Creativity in schools has traditionally been closely associated with arts education, as the teachers most likely to be "receptive" to creativity in their classrooms are arts teachers (Sawyer, 2012, p. 391). It has been argued that arts are "important in and of themselves" (Sawyer, 2012) as part of a society's cultural heritage. More recently, arguments for the arts' capacities with regard to creativity have been that they can enhance cognitive skills which transfer to other disciplines. This would imply that their integration with other content areas (such as science or math) can contribute to more effective learning supported by critical thinking and creativity (Winner, Goldstein, & Vincent-Lancrin, 2013, p. 4–5). Sawyer (Winner, Goldstein, & Vincent-Lancrin, 2013, p. 392) refers to research both in support of the transfer to other disciplines, and research which critiques that approach.[6] Furthermore, it is as yet unclear whether or not the arts may enhance creativity on a more general level (Winner, Goldstein, & Vincent-Lancrin, 2013, p. 392).

Creativity in science education has been defined as "generating ideas and strategies as an individual or community, reasoning critically between these and producing plausible explanations and strategies consistent with the available evidence" (Craft et al., 2016). According to Craft et al. (2016), that kind of creativity relies on teachers' commitment to *fostering* everyday creativity in learners so as to engage those learners in purposive, imaginative activity which generates outcomes that are original and valuable in relation to themselves.

Within the art and science educational contexts presented above, our study exists at a point of tension between pupils needing to learn the "correct" art *and* science curriculum (as defined by the school or educational authorities), and those pupils' participation in the creative, emergent process of WASO. The "ubiquitous creativity" rhetoric resonates with WASO being attainable for all: pupils are not graded for their participation in WASO, and WASO is not more suitable for one pupil over another. Furthermore, this study also exists in tension with the notion of the arts as supportive of effective learning in other subjects, in this case science or math (Sawyer, 2012, p. 391). While we do not exclude the arts' potential in that respect, our primary aim here is to articulate the kind of creativity attainable in a design in which the arts and science exist on equal footing and are both ends in their own rights. Resolving the tensions mentioned here thus necessitates study of an educational design which assigns equal value to the art and science disciplines in order to situate the importance of the arts "in and of themselves" (Sawyer, 2012, p. 391) with the necessity of reliance on *evidence* in science education within a single educational process. We thus set out to explore both practical and theoretical knowledge for the future design of WASO, and learn more about which implications the kind of creativity which characterizes WASO has for the WASO design. To this end, data was analyzed in light of WHC, a theory of creativity in education which links creative activity and identity (Chappell, Craft, Rolfe, & Jobbins, 2012; Chappell, Pender, Swinford, & Ford, 2016; Craft, 2014; Craft et al., 2016).

WHC synthesizes the Humanizing Creativity theory (Chappell et al., 2012) and the concept of "wisdom" in creativity (Craft, Gardner, & Claxton, 2008, p. 3). Humanizing Creativity is theorized as an "active process of change" (Chappell et al., 2012, p. 3). Change comes by inviting pupils to engage in collaborative thinking (Chappell et al., 2012, p. 1) in order to develop new ideas. Individuals contribute while negotiating the needs of others, resulting in shared ownership of ideas. This process may include friction (Chappell et al., 2012, p. 3) as it prioritizes engagement with the values of others rather than individual advancement. Guided by compassion and shared values, young learners go on a "journey of becoming" (Chappell et al., 2012, p. 22). They are "making and being made" (Chappell et al., 2012, p. 23). That making is happening responsibly, and is mindful of needs of others.

Wisdom in educational contexts has been described as relying on characteristics of knowledge, mental capacities and virtue (Craft et al., 2008, p. 3). Acting wisely involves balancing "competing intrapersonal, interpersonal, and extra-personal interests over short and long terms" (Sternberg, 2003, p. 158). Wisdom furthermore "balances adaptation to, shaping of, and selection of environments, in the service of a common good" (Sternberg, 2003, p. 158). For this reason, Sternberg explains (Sternberg, 2003, p. 166) students are required to take on a more active role when teachers implement teaching based on wisdom: those students are called upon to construct knowledge not only from their own point of view, but also from the point of view of others (Sternberg, 2003, p. 166). Wisdom thus perceived should be an essential goal in creative work in education (Craft et al., 2008, p. 5). Taking this one step further, the curriculum *itself* would benefit from greater subject integration (Sternberg, 2003, p. 167) as that requires exploring disciplinary knowledge from the point of view of other subjects.

In WHC, creators must consider ethical consequences of their creations *and* their own identity development as fundamental components of the creative process: while creating and implementing their ideas, creators develop themselves and their co-creators. WHC thus implies that pupils *create themselves* during creative work. They are *becoming* themselves. In the case of our current study, that journey of becoming materializes through creative partnerships between the sciences and the arts, echoing Sternberg's (2003, p. 167) thoughts on subject integration. More specifically, Hathaway and Chappell (2015) identified five features evidencing WHC which were applied and adapted for use by Chappell et al. (2016). These guided the data analysis of the current study:

- Making and being made—the reciprocal core relationship between creativity and identity, and the related notion of humanizing journeys of becoming.
- New ideas that matter—that creativity has the capacity to be humanizing when it is carried out with ethical consideration as part of creative value judgments in relation to what matters to that particular community.
- Working on your own and with others—that creativity occurs individually, collaboratively and communally and often within a shared group identity, that a dialog fundamentally drives it between the inside and the outside.
- Immersion in creating—getting lost in an embodied creative flow in order to take risks and develop new, surprising ideas.
- Taking and sharing control—initiating and sharing the development of creative ideas, and understanding/applying the principles that might guide decision-making.

In choosing to use WHC theory we are acknowledging the existence of other theories relevant to the creativity phenomenon (within the field of education and beyond) with which we did not choose to frame our work. Indeed, the field of creativity research is vast, largely due to a growing number of studies in recent decades (Sawyer, 2012, p. 439–441). Our choice of WHC theory as a framework was based on the following elements of the educational process typical to WASO which potentially resonate with WHC: firstly, WASO relies extensively on group work during which pupils are dependent on input of their peers and teachers in order to create. Secondly, WASO relies on constant dialog between pupils and teachers dealing with science, and their counterparts dealing with the arts, at any given moment. Thirdly, WASO is structured so that pupils must continuously accept their own personal ideas being merged with ideas of others. They must also accept that the individual's personal interests are not the main focus of the process. WHC thus enabled us to situate an active process of change for both pupils and teachers through *collaborative* activity, together with pupils' responsibility to take on more active roles during teaching.

Our motivation for using WHC in this study was, furthermore, our understanding of the large potential which environments such as WASO have as creative environments in which art and science stand on equal grounds despite agendas of arts and science teachers which may be "competing" (Sternberg, 2003, p. 158). Specifically, such "competition" may occur with regard to time and resources in schools in which controlled and monitored curricula are the norm. Before presenting the resulting findings, we will first detail our methodological approach.

4. Methodology

4.1. Research design
This study used a generic approach to qualitative research (Lichtman, 2010, p. 88) in which traditional approaches in qualitative research were adhered to. We aimed to hear the voices of those studied (Lichtman, 2010, p. 69), using ourselves as researchers and thus the bearers of interpretive lenses. Our research results rely on the spoken and written word to a great extent. We have provided direct quotations in order to strengthen the voices of participants. Author 1 was involved in both research sites, including planning and implementation in addition to data collection and analysis.

The research methodology was Educational Design Research (EDR), a genre in which iterative development of practical solutions to complex educational problems also provides context for empirical investigations that produce theoretical understanding and which can inform the work of others (McKenney & Reeves, 2012; Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). Using EDR as a research framework, we aimed to respond to increasing demands from society for educational research to be a vehicle for innovation in educational practices. Furthermore, EDR enables conducting research "through" and "on" the same educational intervention (McKenney & Reeves, 2012) thus enriching results by contextualizing them in additional findings. The current study represents research on the WASO design while corresponding to another study based on data collected during

the same two iterations. The latter provided empirical evidence and new knowledge regarding the pre-service teachers' handling and training for Pedagogical Improvisation within the WASO context (Ben-Horin, 2016).

4.2. Data collection and analysis

Data were collected from a sample of participating teachers which included pre-service teachers (PSTs) and in-service professionals. The reasoning for this was twofold: firstly, the study was supported by a grant focusing on teacher education, and specifically the practicum training of PSTs with in-service teachers (Western Norway University of Applied Sciences, 2014). Secondly, the aim was the provision of new knowledge regarding how creativity may be characterized in WASO and the implications that may have for its design as a teaching practice. Data were consequently collected from teachers (in-service and pre-service) who were active in one of two iterations with 3rd graders (ages 8–9) at two schools[7] in a small town in Western Norway: "Saga" School in 2014 (during which 4 PSTs took part) and "Room" School in 2015 (during which 7 PSTs took part). Several preparatory meetings were conducted between author 1 and all the teachers (in and pre-service). PSTs received approximately 4 h of WASO training prior to their participation. During these preparatory sessions, they experienced some crucial processes related to WASO, and specifically how the choice of a scientific theme is approached as an integrated part of an arts-education exercise.

Participants who provided data were all women. They included 11 PSTs, a visiting drama teacher active during the first iteration, and one[8] of the in-service teachers in the second iteration. Data included reflection notes provided by each PST, aimed at recording personal thoughts and emerging insights (Creswell, 2002, p. 203). These were structured following a set of pre-defined questions defined by author 1 in dialog with the PSTs' Pedagogical counselor. The questions were aimed at learning about the personal experiences of the PSTs, their thoughts and insights regarding creativity at the intersection of art and science educational practices, and their consequent thoughts and insights regarding how WASO should be designed in the future. Two interviews were conducted (one each with the in-service teacher and the visiting drama expert) several weeks after each respective iteration. These were designed and conducted by external researchers for the following reason: author 1, with the support of author 4, was the main developer of the WASO educational environment. New, external viewpoints in the data collection process were thus planned to increase the study's credibility. In both cases, the external researchers were well-informed regarding the study's purpose and scope. The interview with the visiting drama teacher (at "Saga" school) was conducted by an external researcher from a non-Norwegian institution (author 1 took part in the interview which was conducted in a conversational style). The interview with the in-service school teacher (at "Room" school) was conducted by an external researcher from a separate Norwegian institution. The interviews were transcribed verbatim. Data were coded in the original language in which it was written[9] using Hyper Research software (version 3.7.3).

In summary, the data-set included 11 written reflection notes (one by each of 11 participating pre-service teachers), and 2 transcribed interviews (with a visiting drama teacher at "Saga" school and an in-service teacher at "Room" school).

Data analysis began as an inductive process in which we aimed to gradually progress from specific findings to a more general understanding (Lichtman, 2010, p. 5). During the process, additional codes, relating to the articulation of creativity, were added. These supported our efforts to frame the study's findings that correspond to the first research question, as WHC categories. The findings section on characterization of creativity in WASO is thus a mixture of inductive and deductive reasoning, while the "Educational Design" findings section is mainly inductive and emergent. Analysis followed several layers which included triangulation (Creswell, 2002, p. 280) with regard to the variety of data (interviews and reflection notes), kinds of participants, and who was collecting the data. A first set of preliminary codes were applied to the PST reflection notes by author 1 shortly after the second iteration. The interviews were added to the reflection notes to create a combined data-set following the second iteration. Author 1 consequently revisited and refined the codes to create the complete

data-set. A preliminary outline of themes for findings was then critiqued by author 3 before a final result was reached. The credibility and trustworthiness of analysis results are thus based on the triangulation by two persons, as well as on the richness of the data which was collected following intensive periods of immersion in the WASO environment on the part of participating teachers.

4.3. Ethics
Research[10] adhered to the ethical standards of the Norwegian Center for Research Data (NSD, 2017), and was registered with NSD (project reference number 35565). All names of participants and schools have been anonymized. All adult participants were notified of the research taking place and given the opportunity not to take part. All pupils' parents were notified, and use of data adhered to agreements regarding the use of data which those parents have with the schools.

5. Findings
Analysis yielded findings relating to our research questions. Following a presentation of findings,[11] we provide theoretical building blocks as outcomes of relevance for future educational researchers, in our Discussion section.

5.1. Characterizing creativity in WASO
This section focuses on emerging themes relevant to creativity, and an elaboration of those themes from our chosen theoretical standpoint of WHC. We have, therefore, arranged this section following the five features of relevance specified by Hathaway and Chappell (2015): *making and being made; new ideas that matter; working on your own and with others; immersion in creating; taking and sharing control.* The section ends with additional themes which emerged beyond the WHC features.

In general, participants considered WASO to be a creative educational environment for primary schools. Participants' invoking of the term "creativity" did not, however, rely on a specific theoretical underpinning of the creativity phenomenon. Rather, creativity was generally associated with doing things "differently", in a "new" way, or with teaching which includes arts-education. This was not surprising, as preparation of teachers and PSTs for the WASO iterations mainly prioritized training for its implementation practice, rather than on an extensive provision of theoretical knowledge of WHC.

5.1.1. Making and being made
An emerging theme was the capacity of both pupils and teachers to experience and exhibit personal growth during WASO, or in its immediate aftermath. This personal growth occurred with respect to a variety of personality traits, and is emblematic of participants' partaking in a creative educational process while simultaneously building their own identities. The aspect of personal growth of pupils was exemplified by Caroline, the school teacher: "… this wasn't easy for all (the pupils), right? But they succeeded. And even small activities were very big for some of them … for some of them this was very developing in a way … daring to try …" Caroline also specified that WASO supported growth of children whom she described as "creative": "Those who are creative got the chance to unfold themselves more than they'd usually do during regular teaching."

PSTs experienced a reciprocal relationship between creativity and their identity as future teachers and as persons. Caroline described this by explaining that following the WASO practicum, PSTs "said they were very pleased for having taken part, as they were now much more secure as teachers due to the fact that they had challenged themselves during WASO." PST Brita had "developed myself a lot." PST Chloe explained that "I learned a lot, and gained new experiences which I thought would be (too) difficult before I began, but which have shown themselves to go fine. I've grown both as a person and student." Findings thus supported the articulation of the creative process as developing both the pupils and their teachers in similar ways.

5.1.2. New ideas that matter

Our data included an abundance of examples of how, and under which circumstances, ideas were created by both pupils and teachers. Analysis has pointed at what idea creation in the inter-disciplinary WASO environment represents with respect to WHC theory.

PST Iselin provided a typical witnessing of idea creation in WASO as "we were going to create an opera about the multiplication table ... we got new ideas as the time went by, and the pupils had good ideas which we wanted to use later on in the project." A good example of a pupil valuing that which matters for the community was given by PST Astrid, who documented a pupil as saying the following after the opera performance: "I think it was fun to perform it, and I hope they (audience) had a nice time and that they learned something ... after all, that was the meaning of our opera." Kjerstin, the external drama instructor, acknowledged her lack of expertise as a science teacher and consequently explained how ideas came to her through dialog with a science teacher thus: "We (art teachers) are not scientists ... we came here to invite you to interact with us." She also specified that collaboration through dialog is especially crucial at the beginning of each WASO iteration.

5.1.3. Working on your own and with others

Activity in WASO is mostly organized as collaborative group work.[12] Most data thus related to contexts in which participants were working with others. The theme which emerged most clearly regarding working with others was that of teachers' relations to pupils. PST Samantha described that it "was unbelievably fun to build relations to the pupils in a different way than would have been the case with regular classroom teaching." Furthermore, WASO was characterized by Kjerstin, the drama teacher, as "necessitating communication all the time." That communication occurred between various kinds of participants (pupils, PSTs, in-service teachers). Kjerstin explained that in order for pupils to express scientific knowledge through the arts (and with emotion), they needed to first initiate communication with both art and science teachers. PST Chloe explained that pupils understood that the teachers did not know everything about the learning subjects (which were often emergent as a result of WASO's improvisational character), and how they would all find out more, together. Indeed, according to PST Gunvor, scientific questions about the subject of temperature which had been generated by pupils during the beginning of the WASO iteration (e.g. what causes the wind to blow or the rain to fall) were "answered during the performance."

Teachers were dependent on direct dialog with each other in order to realize their intentions. Kjerstin explained that this was especially true in the case of art and science teachers working together. Finally, PST Chloe described how the scientific theme of the second iteration opera, temperature, was in itself a "common thread" between the various disciplines of the arts (e.g. music and visual arts) and science, thus functioning as an initiator of collaboration.

Analysis did not yield conclusive evidence regarding the actual *balancing* of working alone and with others. Yet, our analysis did yield evidence of how the individual creative process may be characterized. PST Astrid described it metaphorically thus: "WASO had a good connection between science and art, (and) I believe the pupils developed more understanding and many hooks to hang their knowledge on." PST Gunvor explained that "I believe that most of the pupils will have lots of knowledge about this, and that they will remember it well." How each pupil made sense of the creative task, and the corresponding translation of it into memorable knowledge, happens individually. The enactment of understanding themes across subject boundaries characterizes the individual pupil's creative process in WASO.

5.1.4. Immersion in creating

Evidence of immersion in creating was limited to group interactions which included "group flow" (Sawyer, 2012, p. 245). Immersion as evidenced through "flow" experienced by single pupils or teachers did not emerge as a major theme during analysis.

Evidence of "group flow" was connected to emergent products and improvisational situations (Sawyer, 2012, p. 245), or to the existence of what teachers perceived as satisfactory communication procedures (between practitioners of science and art and among PSTs). PST Isabel described an emergent group process during which she and another PST improvised towards a solution together with pupils as having "gone very well, because we could talk a bit together as we improvised and explained (to pupils) ... and helped each other when there was a need for that." Kjerstin described the emergence of products suitable to the problem as being dependent on sufficient group communication: "It was actually a direct communication with me, with the science teacher, and then of course the music teachers in matter of how you can express it (the opera's subject matter) with emotion." With regard to pupils, PST Gunvor described absorption in the process of the opera creation thus: "Without pupils being aware of it, the opera formed itself more and more into a complete entity." The prospect of collaborative group work leading to a result which surpasses what any one member could have achieved on her/his own, typical of group-flow (Sawyer, 2012) is therefore well-documented in WASO.

5.1.5. Taking and sharing control

Taking and sharing control during development of creative ideas was a topic frequently referred to in the data, from a variety of perspectives: the theme which emerged most often was that of the interplay between teachers' pre-conceived planned structure, and their balancing that plan with the handing over of control to pupils. This was challenging for teachers, but was generally considered to have functioned well. PST Brita explained how "that was one of the things I found challenging with this project, to let pupils have their creative process at the same time as I should steer them towards the correct theme and theory." She also added, though, that "PSTs and (in-service) teachers all succeeded in steering pupils towards the scientific theme of temperature." PST Rebecca added that "WASO is based on improvisation ... we adults improvise based on pupils' inputs throughout the whole process." PST Gunvor added that "even though I had the big picture, most of what we did was realized following how the pupils worked together, and what they considered important." Finally, PST Astrid commented about sharing and taking control in the context of the opera's production: "the pupils led and made everything." In relation to this, she added that "I (previously) believed I needed to have full control in order to master something ... that belief has luckily proven to be false." The drama instructor, Kjerstin, addressed taking and sharing control between teachers of different disciplines in WASO. She acknowledged the importance of a close collaboration with the math teacher during the first iteration as follows: "The math teacher is equal to me, together we stand."

5.1.6. Additional emergent themes

During analysis, two themes emerged as being closely related to the creative process which are not directly specified in the WHC features: improvisation, and the inter-disciplinary art and science environment as being creative due to its very definition. While these two themes do appear in the findings presented above, we consider it of importance to specify them as additional emergent themes in order to enrich the study's results and point out aspects of our analysis which are not fully explained by WHC.

WASO emerged as not only *containing* improvisation but actually being an *improvisational* process. PST Rebecca explained that the process included unforeseen elements, and that teachers often improvised with both content and teaching structure: "... we as adults improvise based on pupils' associations throughout the whole process". She added that "WASO is based on improvisation." This could point at a fundamental relationship between improvisation and the creative process in WASO well-worth additional exploration.

An emergent theme was the participants' referral to WASO as creative due to its being different than standard teaching methods, and specifically due to its reliance on an inter-disciplinary structure based on both art and science education goals and practices. PST Chloe described it thus: "We worked in creative ways by making sounds and music to scientific elements in nature such as water drops, fire, leaves, volcanoes, etc." PST Gunvor explained that she "thinks this was a very creative

way for one to learn about temperature." PST Lina added that "to be able to work alot with music, movement, and visual arts in addition to other subjects, has been creative." PST Mariann explained that pupils "got to work with (and learn about) temperature in a very varied, nice and creative way." The inter-disciplinary bringing together of various school-subjects, and the cross-inspiration involved, thus *in itself* seemed to qualify WASO as being creative in the minds of participants. As in the case of improvisation, this theme does indeed resonate with WHC, although WHC does not theorize the intersection of art and science per se.

6. Findings regarding the educational design

In this section, we present emerging themes relevant for the design of future WASO interventions in primary schools, and specifically in relation to the findings mentioned above regarding the characterization of creativity in WASO. Though they often are inter-connected, themes are distinguished as pertaining to either pedagogical or structural considerations.

6.1. Pedagogical themes

Several findings emerged as new insights into the pedagogical potentials and challenges that demand consideration during WASO. These related to WASO's inter-disciplinary art and science nature, and impact on learning in science, math, or the arts disciplines.

The inter-disciplinary nature of WASO was experienced by participants in a variety of ways. A recurring theme among teachers was the necessity for a quality process in both science and art in order for all participating teachers to consider the process to have been satisfactory with regard to existing curricula at the same time as it was creative. This implies an adherence to the standards of quality for each separate discipline (as they are defined by each school and for each discipline's curriculum). The inter-disciplinary character of WASO must therefore not disrupt the school's goals for the art and science curricula. For Kjerstin, the drama teacher, this is all about the actual process of finding out "how you can make it work … how you can make a good story … you have to have a good story to actually make it both good science and good drama." Kjerstin also elaborated on the fact that WASO exemplifies learning which directly relates to pupils' emotions, and how those emotions were a driving force for the creative learning process and, correspondingly, for further communication between teachers within various disciplines. PST Chloe observed the same process yet from a different angle by specifying that "the pupils thereby had the arts immersed in science, and the science immersed in the arts." PST Chloe thought the inter-disciplinary character made the work more interesting for pupils, as it was necessary for them to "think more (than usual) about what they were using in order to create things (for the opera)." PST Isabel described this as "pupils needing to think more before being able to show the audience which (nature phenomenon) they are playing (on-stage) … fire, water, wind, etc." PSTs considered the inter-disciplinary work to have been executed well, as PST Gunvor explained: "I feel this was done in a very good way." The mechanism was described by PST Brita who explained that "pupils … got new knowledge every day, which they had to take into use in order to create their performance." It therefore appears that one of the added values of WASO as an educational design is a mechanism by which it has the potential to increase engagement in the educational process. This occurs by WASO's creation of a continuous dependency (on the part of the pupil) on elements of one discipline (e.g. science) in order to solve a problem or complete a task in another (e.g. music). Furthermore, the "carrying over" of knowledge and information across disciplinary boundaries required emotional engagement as a driving force within the creative educational environment.

6.2. Implications for general learning

Teachers believed pupils would remember the science material better and longer due to the inter-disciplinary work in WASO. PST Gunvor explained this as being due to the "many different approaches to the theme (temperature)." The teacher Caroline and PSTs Brita and Astrid strengthened this by providing example of pupils being allowed to do hands-on work with hot and warm colors as supporting their understanding of the temperature concept. PST Astrid added that this understanding occurred "*quickly*." Caroline explained that "I think the learning outcomes they got from WASO were

more important (than regular teaching) … I mean, it didn't matter (that they had had less regular teaching during that time) when we saw what they were left with after having taken part in WASO." These findings would appear to support arguments for the allocation of time and resources needed in order to implement WASO. Despite that, it would appear that the issues of improved memory, the amount of knowledge accumulated about a specific scientific topic, and the long-term effect on pupils' learning are still areas which require further research before any conclusions can be reached.

6.3. Structural design principles

The following sub-section describes structural design principles that emerged during analysis. These took the form of direct recommendations made by participating teachers and/or as themes which emerged hand-in-hand with previous findings regarding characterization of creativity and what implications that characterization may have. In order to contextualize these principles, Table 1

Table 1. Schedule of the WASO process at "Room" school				
	08:30–09:20	**09:20–11:40**	**11:40–12:20**	**12:20–end of day**
Day 1	Class meeting with teacher and PSTs followed by warm-ups	Exercising musical improvisation and composing; vocalizing; creating various atmospheres with voices; playing\clapping different rhythms; teaching basic opera terminology (External music teacher and 2 PSTs)	Break	Exercising the use of color, light, and shadow in an opera's scenography (External visual arts teacher and 2 PSTs)
Day 2		Class divided into groups exercising dramatization of temperature-related themes (group 1) and visual arts focusing on color/light/shadow in opera scenography (group 2) (External drama and visual arts teachers and all PSTs)		Pupils unavailable
Day 3		Science experiment about temperature aimed at generating questions and curiosity as inspiration for the opera. Realized during a visit to the local college (External science teacher and all PSTs)		Science\Art exercise: science experiment and its corresponding interpretation by four pupil groups: Visual arts, music, drama, dance. Finalized with discussion with pupils about relations between science and art (External science teacher and author 1)
Day 4		Working on the opera's synopsis and libretto (External drama teacher and 2 PSTs)		Pupils unavailable
Day 5		Pupils fill out and deliver "applications" to teachers in order to be considered for being assigned "opera company" roles in one of 6 groups: actors/singers, orchestra musicians/composers, opera chiefs (2 pupils), public relations, scenography/costumes, stage lighting and sound technicians (School teacher, external drama teacher and all PSTs)		Informing pupils about the division into roles in the "opera company" based on their applications (PSTs); discussion with whole class regarding preparations (school teacher, PSTs); science teaching based on school curriculum (2 PSTs)
Day 6		"Show and Tell": Each group in the «opera company» presents its progress to the rest of the class (External drama teacher)		Continuation of rehearsals and preparation in groups. (External music teacher and all PSTs).
Day 7		Continuation of rehearsals and preparation in groups (External visual arts teacher, school teacher and all PSTs)		Continuation of rehearsals and preparation in groups (External drama teacher, school teacher and all PSTs)
Day 8		Continuation of rehearsals and preparation in groups (External music teacher, school teacher, and all PSTs)		Pupils unavailable
Day 9		Class discussion; continuation of rehearsals and preparation in groups (External drama teacher, school teacher and all PSTs)		Science teaching based on school curriculum (2 PSTs).
Day 10		Continuation of rehearsals and preparation in groups (External music teacher, school teacher, and all PSTs)		Science teaching based on school curriculum (2 PSTs); class discussion; general rehearsal (All external teachers, school teacher and all PSTs)
Day 11		Performance for whole school (All external teachers, school teacher, all PSTs, author 1)		Pupils have party in classroom (all external teachers, school teacher, PSTs, author 1); PSTs have final reflection discussion with author 1 and external music teacher

(below) first lays out the schedule of the WASO process of the 2015 iteration at "Room" school, during which the science opera "Watery, the elegant water drop and his friends" was created.[13] The various sessions were led by the 7 participating PSTs, an in-service teacher employed at the school, and four external teachers from within the fields of science, drama, music, and visual arts. Author 1 took part as a teacher in a limited number of sessions in order to introduce the inter-relationships of science and art. Class meetings in the mornings were led by the pupils' teacher and all PSTs. Warm-ups were conducted by a different teacher (professional or PST) each day. Each day ended[14] with a staff planning meeting and a brief reflection discussion. The opera was performed for the wider community (e.g. families of pupils) on the evening of day 10, and for the rest of the school during regular school hours on day 11. The function of the teacher who led each session is specified in parentheses.

Data analysis yielded several themes relevant to WASO's structural design. These are presented below as principles that respond to our second research question concerning implications which the characterization of creativity in WASO may have for the WASO design.

6.3.1. Planning

Planning the WASO project usually includes a series of meetings between external teachers, the school's head-teacher, and the participating pupils' teachers. A crucial element, according to drama instructor Kjerstin, is to "have the science teacher on board", especially during the choice[15] of a scientific topic for the opera. Kjerstin specified that this should be negotiated during (at least) one meeting before the pupils begin their work so as to ensure the art and science instructors are setting a common process in motion, and that that process includes the goals and curriculum of each discipline. This finding resonates well with the collaborative approach to creativity represented by WHC, and especially with its specification of the importance of *shared group identity* while working with others.

6.3.2. Daily structure and scheduling[16]

In WASO, pupils (and teachers) are taken out of their usual setting and continuously required to create new ideas, costumes, music, drama sequences, and relate these to processes occurring simultaneously in other disciplines. Consequently, Caroline, the teacher, explained that "generally, they (pupils) were very motivated. But on some days they were completely tired at the end of the day." WASO teachers must be closely in tune with pupils' needs with regard to rest, balance, and how much (and for how long) they are comfortable with a classroom design which differs from what they are generally accustomed to. Start-of-day sessions during which all pupils are present in a traditional classroom format are thus important. PST Gunvor explained that "even though pupils were participating in a WASO project, the days started as they would (during) normal (schooling). Only half an hour later…the warm-ups would start. I think this was important, because the whole project was so different than their normal school structure, that it was good to have something familiar and stable."

6.3.3. Performance

While it did not emerge as a main theme during analysis, participating teachers did engage in discussions regarding the importance, timing and scope of a final performance of each opera. The reason for this was the extensive amount of time and effort allocated to that performance in order for it to be something which pupils would feel proud of sharing with their whole school and the wider community. Teachers expressed interest in exploring a WASO design in which more time would be dedicated to the creative process of the opera's creation rather than to the preparation of its performed product. While the prospect of a large performance did motivate pupils to "go on," our data also contained examples of the performance deadline (on day 10 of the process) causing pressure, as PST Gunvor exemplified: "there was (too) little time to make the costumes and scenography." An alternative model, during which pupils would be allowed to be immersed in the creative process of developing their understandings of art and science relationships without a performance would, consequently, justify further research, as described in the discussion, below.

7. Summary of findings

The following Table 2 summarizes[17] the study's findings.

Table 2. Characterizing creativity in WASO—identified themes	
Themes relating to "Making and being made"	*Elaboration*
Pupils and teachers experience and exhibit personal growth	Participants partaking in a creative educational process while simultaneously building their own identities by "daring to try"
WASO supported growth of pupils described as "creative"	These pupils had the chance to "unfold" themselves more than during regular teaching
PSTs experienced a reciprocal relationship between creativity and their identity as future teachers and as people	Findings supported the articulation of the creative process as developing both pupils and their teachers in similar ways. The latter could experience having "grown both as a person and (teacher education) student"
Themes relating to the category "New ideas that matter"	*Elaboration*
Analysis has pointed to what idea creation in the inter-disciplinary WASO environment represents for both pupils and teachers	Ideas materialized through the interaction of pupils and teachers as the latter identified "good ideas which (they) wanted to use later on in the project"
	Pupils value that which matters for the community, as part of the "meaning of our opera"
Themes relating to the category "Working on your own and with others"	*Elaboration*
Teachers' relations to pupils in WASO are built differently and have a different character than in regular classroom teaching	Pupils understood that teachers did not know everything about the often emergent learning subjects, and that they would all find out more, together
Pupils need to initiate communication with both art and science teachers in order to express scientific knowledge through the arts (and with emotion). Teachers depend on direct dialog with each other in order to realize their intentions in WASO	The scientific theme may itself provide a "common thread" between the various disciplines
The individual creative process in WASO as an emergent development	The enactment of understanding themes across subject boundaries characterizes the individual pupil's creative process in WASO. This contributed to "more understanding and many hooks to hang their (pupils') knowledge on"
Themes relating to the category of "Immersion in creating"	*Elaboration*
"Group flow" was connected to emergent products and improvisational situations.	Collaborative group-work leading to a result which surpasses what any one member could have achieved alone is evident, a times even "without pupils being aware of it." But this is dependent on sufficient group communication
Themes relating to the category of "Taking and sharing control"	*Elaboration*
Interplay between teachers' pre-conceived plans and their balancing those with handing over control to pupils	Challenging for teachers but generally considered to have functioned well, as both "pre-service and in-service teachers all succeeded in steering pupils towards the scientific theme …"
WASO is improvisational	Most decisions by teachers were "based on pupils' inputs throughout the whole process"
	Taking and sharing control was evident between teachers of different disciplines: "Together we stand." This depends on close collaboration between them
Additional emerging themes	*Elaboration*
Improvisation	"WASO is based on improvisation": There is a potentially fundamental relationship between improvisation and the creative process in WASO which merits additional exploration

(Continued)

Table 2. (*Continued*)	
The inter-disciplinary art and science environment is creative due to its characteristic of bringing various disciplines together in a single process	The inter-disciplinary structure *in itself* qualifies WASO as being creative: "We worked in creative ways by making sounds and music to scientific elements in nature"
The WASO educational design – identified themes	
Pedagogical themes	*Elaboration*
A quality process in both science and art is required with regard to existing curricula in all subjects: "… you have to have a good story to actually make it both good science and good drama"	The inter-disciplinary character of WASO must not disrupt the school's goals for the separate art and science curricula
Pupils' emotions in WASO	WASO exemplifies learning which directly relates to pupils' emotions, and how those emotions drive the creative learning process. The "carrying over" of knowledge and information across disciplinary boundaries requires emotional engagement as a driving force
The learning environment was more interesting for pupils	This was due to the fact that it was necessary for pupils to think more than usual "before being able to show the audience which (nature phenomenon) they are playing (onstage) …"
WASO has the potential to increase pupil engagement in the educational process	This occurs by WASO's creation of a continuous dependency (on the part of the pupil) on elements of one discipline in order to complete a task in another: "Pupils … got new knowledge every day, which they had to take into use in order to create their (inter-disciplinary) performance"
Themes relating to implications for general learning	*Elaboration*
(Some) learning outcomes in WASO were more important than during regular teaching	This is evidenced despite the fact that pupils have less regular teaching during WASO: It "didn't matter (that they had had less regular teaching during that time)" when teachers saw "what they (pupils) were left with after having taken part in WASO"
Themes relating to structural design principles	*Elaboration*
Planning for WASO	The art and science instructors must set a common process in motion. From the art educator's perspective, s/he must "have the science teacher on board"
	Goals and curriculum of each discipline must be respected
Daily structure and scheduling	WASO teachers must be closely in tune with pupils' needs with regard to rest and balance "because the whole project was so different than … normal school structure"
	Start-of-day sessions during which all pupils are present in a traditional classroom format are important
The performance	The final performance's length, timing, and scope was a topic of debate among teachers. The prospect of a large performance motivates pupils to persist and "go on," but may also cause pressure. An alternative WASO design, without an extensive performance would thus justify further research

8. Discussion

WASO is perceived by teachers to be a creative educational environment. Yet, teachers lack a clear concept of how to describe creativity in WASO. Typically, they consider WASO creative due to it being different than traditional teaching, its reliance on arts education methods, and its improvisational elements. WHC is a theoretical approach to creativity in education which provided a framework within which the kind of creativity WASO offers participants during (mainly) collaborative group work could now be articulated: WASO facilitates collaborative creativity for both pupils and teachers

(PSTs[18]). Indeed, analysis provided examples of pupils and PSTs undergoing shared, emergent creative processes in which participants go on a "journey of becoming" (Chappell et al., 2012, p. 22) by creating based on shared values with others. Together with others, they develop ideas that matter for themselves and their community. By wisely recognizing a "common good" (Craft et al., 2008, p. 158), pupils become immersed in the collaborative creative process. By balancing the taking and sharing of control, pupils create *themselves.*

Data analysis did not, however, produce conclusive evidence in three areas relevant to the WASO creative process, and which would therefore merit further study. Firstly, analysis did not yield good examples of how the balancing of working on one's own and with others, a feature of WHC theory, may be characterized. Secondly, no conclusive evidence relating to characterizing creativity within the separate, individual disciplines[19] in WASO (e.g. science or music), emerged. Thirdly, while emergent knowledge and improvisation were well-documented in our data, the characterization of the inter-relationship of improvisation and creativity, and how that inter-relationship works specifically within WASO, did not emerge as a major theme. Sawyer's (2012, p. 367) perspective on improvisation as *always* being involved to some extent in creative processes (as those processes are never fully predictable) strengthens the need to explore this area further. Following a discussion of several implications of the creative process on the WASO design, our discussion addresses the need for these areas which were not evidenced, and puts forth thoughts towards future research.

WASO represents a creative process in which various disciplines optimally co-exist on equal footing. The implications that creativity as articulated in this study have for WASO's (evolving) design with respect to structuring and scheduling relationships between arts and science sessions must therefore be considered and made more explicit in the future. In our data, concrete recommendations referred to how each WASO iteration should be set in motion by a combined effort of art and science teachers, in dialog. For pupils engaged in a process within a given discipline, *dependency* on input from others (who are engaged in an activity in another discipline) in order to create, necessitates a constant need to understand concepts (such as temperature) across subject boundaries. That need is negotiated through communication in a social context. While a definitive conclusion as to how this should be implemented in practice may be premature, our discussion must address the role of this aspect of the WASO design in future research. The design should therefore include the setting in motion of a process during which pupils experience dialog between disciplines (see Figure 1), making explicit co-creation *across disciplinary boundaries.* Specifically, the WASO class may be divided into two groups. One group is given an arts education task, the other a science education task. Upon completion, each group takes over the other group's results and a new task is given which builds upon the previous task: the group previously working with an arts task now continues the science task of the other group, and vice versa. The process continues for several rounds until pupils recognize that they have collaboratively undergone a process (and created a product) in which art and science are intertwined. The inter-disciplinary "dialogue across art forms" evidenced by Chappell et al. (2016, p. 268) in their application of the WHC features, is thus here extended to dialog between art and science disciplines. This would seem to resonate well with Sternberg's (2003) description of pupils constructing knowledge from the point of view of others. Wisdom, he claims "balances adaptation to, shaping of, and selection of environments, *in the service of a common good*" (Sternberg, 2003, p. 158, italics added).

The communal features of WHC are represented in WASO mainly on the receiving side, in the form of audience members invited to witness a ready-made performance. Allowing the community to provide *input* to the opera would resonate with the dialog feature of WHC while at the same time providing real-life inspiration to pupils. A consequent implication for the evolving WASO design could be the inclusion of local science or technology industrial or research institutions in the process by inviting them to provide real "research questions" as inspiration for the opera's scientific topic.

Figure 1. Continuous dialogue in art and science.

Source: Ben-Horin (2015).
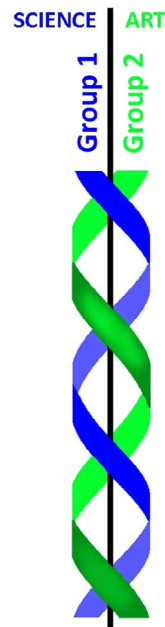
8.1. Beyond WHC

While WHC provided an ample framework for the study, some themes which emerged in the findings justify further discussion based on other theoretical sources.

Burnard (2012) has shown how even within the scope of a single art form (music), reference to "creativity" may be misguiding. Rather, she argues, there are "all kinds of *creativities*" (p. 31, italics added) to be explored within music. Some examples of these, all of which may be relevant to the characterization of creativity in WASO's musical activities, are creativity in relation to specific musical instruments (p. 12); various kinds of musical creativities found within the "nooks and crannies" of the World Wide Web (p. 13); differences between adult and child musical creativity (p. 23); creativity as exhibited by participating audience members (p. 34); and creativity in relation to musical production (p. 43). It follows that the discussion could be enriched by moving beyond articulation of "creativity" in WASO, as that may be too narrowly defined. This is certainly the case for the multi-disciplinary process of WASO, in which science, visual arts, drama and music co-exist in dynamic interaction. Studying *creativities* in WASO, both within each discipline and in the interaction between them, and especially when various disciplines co-exist on equal grounds, would thus be an area worthy of future research.

Chappell et al. (2016) wish to contribute to the debate in favor of a less risk-averse education with their work on the WHC features (p. 275). They stop short, though, of conceptualizing that risk within the creative context. Biesta (2014) has approached creativity from the point of view of creation (p. 11) and the risk which creation entails. He compares an educational process conceived of in a *strong* sense, "as the *production* of something" (p. 11), with one conceived of in a *weak* sense. The latter entails a releasing of control over the (creative) educational process and its outcomes. An educational process in the weak sense entails risk on the part of teachers, as it is emergent and impossible to plan for in all its detail. A weak educational process avoids an attempt to eliminate risk from the educational setting. Rather, embracing risk supports a fundamental goal of education, namely, its aim for "freedom and independence of those being educated" (p. 2) by allowing for subjectivity to emerge in "always new, open and unpredictable" processes (p. 12). Biesta's perspective may thus help deepen some of the themes presented in our findings, above. Specifically, WASO's being based on improvisation and emergent (and therefore risky) ideas: Biesta's conceptualization of the releasing of control over the creative educational process as being *beneficial* and of representing an *end in*

itself is thus of value for this discussion as it may provide teachers with a clear concept of what they are striving to accomplish with WASO (and why), and of how to prepare themselves to reach that (Ben-Horin, 2016).

WASO could, in theory, be implemented without a final performance, making it more similar to "regular" teaching. This would also keep the focus solely on the creative process of the opera's creation, rather than investing time in communicating the "product" outside the classroom. As both iterations researched here echoed the original Write an Opera practice (Royal Opera House, 2012) of a public performance, the authors refrain from drawing any conclusions as to the pros and cons of a "no performance" approach. We do, though, wish to stress the fact that for us, the important creative process during which ideas and solutions emerged through improvisational group-work, happened during each opera production's preparation and creation by pupils. This was why we chose to analyze the process leading up to the performance, but stopped short of analyzing the performance itself. We do not exclude the importance of the performance, or of its being a creative act in its own right. Indeed, as quoted in the preamble to this article, PST Isabel evidenced how pupils needed to develop an understanding of the various disciplines in order to communicate new knowledge to the audience. Another angle through which this issue may be observed would be the exploration of the merits of an educational design in which a more extensive amount of time is allocated to WASO, or the same amount of time spread of several months. This would allow more time for the preparation of the final performance (Sousa, Ben-Horin, Ramos, & Lopes, 2016). The role of the performance in WASO thus merits further research.

9. Conclusions

This research aimed to produce practical and theoretical knowledge regarding the design of an inter-disciplinary, creative educational environment as a consequence of how creativity could be characterized within that environment. Data were collected and analyzed within a framework of Educational Design Research. Research was conducted *on* the educational design. Additional research, conducted *through* the same environment, relating to teachers' planning for, and implementation of, pedagogical improvisation, has been described in other settings (Ben-Horin, 2016). This research was conducted at two Norwegian primary schools with a sample of 13 teachers as participants. In both cases, pre-service teachers (PSTs) had an active role in leading a variety of educational activities as part of their practicum training to become teachers.

Findings have supported the characterization of creativity in WASO according to WHC theory with the exception of specific knowledge regarding how pupils balance working on their own and with others. Inter-disciplinarity has been found to function as a motor for an emergent, improvisational process characterized by extensive collaborative group work. Where group flow (Sawyer, 2012) was observed, that flow was largely linked to WASO's improvisational character. Sawyer described group flow as an "improvising team (which) creates a novel, emergent product … more suitable to the problem than any one team member could have developed alone" (p. 245). This implies that WASO may always be realized as interplay between a pre-planned structure and an in-the-moment implementation. The improvisational character of WASO and the risk (Biesta, 2014, p. 11) which that improvisation entails, should not, therefore, be avoided, but welcomed as a fundamental element in the creation of the pupils' group identity during the process.

Evidence of the creative process of individual pupils was limited to pupils' making sense of concepts across disciplinary boundaries. Several concrete instances of how this was done, and to what effect, were exemplified in the data. We could not, however, characterize how ideas are generated by individuals in WASO. Furthermore, while data did include some references to WASO's potential impact on pupils' ability to remember the scientific topics studied during the process for longer periods of time, it was not possible to reach any conclusions as to the validity of these claims.

WASO, as a creative educational environment, provides several potential advantages with regard to relations among participants. In order to reap the benefits of those advantages, several structural considerations must be adhered to. That said, the authors refrain from describing an "ultimate" or "definitive" structure for WASO. We refer to the design principles presented above concerning planning procedures, daily schedules and the conceptualization of the opera's performance, as points of reference. The detailed, specific structure of each implementation of WASO must be negotiated by each school anew for the following reasons: firstly, the specific implementation of each WASO project must be adapted to needs, capacities, available rooms, schedule and interests of each school. Secondly, the WASO design studied here was implemented over a period of 2.5 weeks in each school, implying that the teachers had access to the pupils for (roughly) 11 working days. Thirdly, WASO is resource-intensive with regard to human resources, time, and pre-project planning. It tends to focus on a smaller "amount" of the science curriculum than may otherwise had been taught while employing traditional teaching methods. That balance must be negotiated by each school in accordance with its preferences.

These conclusions merit further research of the WASO environment. The current study succeeded in articulating the *kind* of creativity observed, mainly in group settings of distributed and collaborative work. Of particular interest would be a complementary study which would analyze *how* creativity emerges in WASO. To do achieve this, a similar study would need to be realized during which the voices of pupils, not teachers, are listened to. Furthermore, several educational initiatives have implemented longer (Sousa et al., 2016) or shorter (Craft et al., 2016) WASO environments, yet a study which compares the effects of varying lengths has yet to be realized. Finally, an approach which recognizes *creativities* rather than *creativity* would be beneficial, as WASO contains within it a large variety of types of activities, within several educational disciplines, in constant interaction.

Pupils' own emotions (OECD, 2015) emerged as a driving force for learning in WASO, as opposed to government-dictated mandates as driving forces: WASO allows pupils to develop their identities as groups by tackling the complex task of producing a science opera as the outcome of their own ideas and their own eclectic way of observing and exploring. This is a fulfilling yet demanding task. While the end result cannot be foreseen as it is emergent, pupils and their teachers intuitively know they are working towards it together, as a group which reaches higher than the sum of its single members. As stated above, this work is anything but easy for the pupils or their teacher. In order for a more widespread implementation of WASO to be enabled, educational authorities will need to be convinced that the potentials described here merit further exploration into the balance between the advantages WASO facilitates, and the investment of resources and teaching-time which that would entail: the importance of creativity for the school of the future is undisputed (NOU 2015: 8, 2015). The ability of pupils to explore the curriculum creatively will have many implications (NOU 2015: 8, 2015, p. 22). WASO offers pupils a way of understanding common themes and questions across disciplinary boundaries, a desirable characteristic of the school of the future, and which has here been characterized as creativity exemplified by the individual pupil. This resonates with the Norwegian Government's "Deep Learning" vision for the school of the future (NOU 2015: 8, 2015, p. 53). A more wide-scale implementation of WASO would, though, necessitate further steps in its development as a prerequisite. Specifically, following research of WASO's design in more diverse circumstances (additional age groups, countries, and scientific themes), its definition not as a creative educational environment, but as a methodology.

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Notes
1. The term "science" here takes on the more general meaning of Science, Technology, Engineering, and Math (STEM). Hence, both math and physics (temperature) were included in the iterations.
2. The term "iteration" refers to one implementation of a WASO project in a single school. The term has been chosen as it resonates with the iterative process on which Educational Design Research (McKenney & Reeves, 2012) is based.
3. The Write an Opera method always includes a performance of the created opera at the end of the process. In WASO, there has been ongoing discussion among practitioners regarding whether or not a performance should be prioritized: an extensive amount of time and effort need to be allocated to that performance for it to be something which pupils intuitively feel proud of. While the two iterations of WASO which provided data for this study both included performances, the question of that performance's role and value, especially from a science teacher's perspective, still necessitates research.
4. In-service teachers took part in a series of preparatory meetings. PSTs took part in meetings as well as WASO workshops in order to learn its mechanisms. As described below, both meetings and workshops focused on preparing for implementation of WASO rather than an in-depth study of WHC theory.
5. See Chappell (2008) for a more detailed description of creativity rhetorics' interactions with Humanizing Creativity theory.
6. A summary of creativity research in a variety of arts disciplines (music, visual arts, and drama) is provided by Sawyer (2012).
7. The specific schools were chosen for their belonging to a network of schools which provide practicum opportunities for PSTs at the college at which authors 1 and 4 were employed, and for their willingness to accommodate the study. The number of pupils who took part in WASO at each school was 26 ("Saga" school) and 32 ("Room" school).
8. The second iteration at "Room" school was originally supposed to include two in-service teachers. However, due to one of them being on sick-leave, only one of them was active during the iteration.
9. All data were produced and coded in Norwegian except for the interview with the drama teacher which was conducted and coded in English. Data quoted in English (in "Findings", below) was translated from Norwegian by author 1.
10. The research was funded by the Norwegian Research Council as part of the «Improvisation in Teacher Education» project (Western Norway University of Applied Sciences, 2014).
11. Words in parentheses were added by the authors for clarification.
12. Activities typically include the complete class in one big group during the first 2–3 days. These are gradually reduced to approximately 3–4 pupils per group focusing on specific activity areas as the WASO iteration progresses.

Finally, for the performance and reflection session, the whole class again works as a single large group.
13. The original Norwegian title was "Vanni, den elegante vanndråpen og vennene hans".
14. Pupils' school days ended at varying times on different days of the week.
15. As the choice of topic (e.g. temperature, multiplication table) is only a general one, the opera's specific story and content is left up to the pupils.
16. Scheduling a WASO project is a challenging process, and first-time teachers are notified in advance that schedules may need adjustment during the process (Ben-Horin, 2016).
17. Where appropriate, data excerpts are provided.
18. While WHC would, in theory, allow for professional (in-service) teachers to engage with pupils (and PSTs) in a collaborative creative process, this was not evidenced in the data.
19. Although WASO is an inter-disciplinary project, several whole-class and group sessions were dedicated to the teaching of single disciplines (such as musical composition or the multiplication table). While our research was aimed at providing knowledge regarding WASO's inter-disciplinary nature, we acknowledge the potential for creative activity within these specific disciplines.

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