International Journal of Environmental & Science Education
(2014), *9*, 21-39

Influences on students' environmental self determination and implications for science curricula

Rebekka Darner
Illinois State University

Received 10 August 2012; Accepted 17 June 2013

Doi: 10.12973/ijese.2014.201a

According to self-determination theory, social contexts that support students' basic psychological needs of autonomy, competence, and relatedness foster motivation toward behaviors that are valued in that social context. This study investigated the socio-contextual elements of a learning environment that support or undermine students' basic psychological needs as they relate to solving environmental problems. Individual stimulated-recall interviews were conducted with a student group after they participated in environmental problem-solving tasks over the course of a semester. Data were taken on students' reported feelings of competence, relatedness, and autonomy, and the classroom features to which they attributed those feelings. Six features of the instructional environment were inferred to be supportive of students' basic psychological needs. These are referred to as *curricular interconnectivity*, *conceptualization problem sets*, *instructional guidance*, *socio-scientific integration* throughout the curriculum, *student-guided lecture*, and *cohesive group dynamics*. One feature of the instructional environment seemed to undermine students' basic psychological needs; it is referred to as the *"anything-goes" norm*. These features are explained with supporting evidence and consequences regarding students' needs for competence, autonomy, and relatedness. The article concludes with a discussion of considerations when constructing science curricula, given the impacts on environmental motivation.

Keywords: curriculum design, environmental motivation, self-determination theory

Introduction

Environmental educators strive to produce scientifically literate citizens who make informed decisions, especially when those decisions have environmental consequences. Darner (2009) has proposed the use of self-determination theory as a guide for the construction of environmental education (EE) curricula that foster environmental self-determination. To provide a definition of environmental self-determination, we must first explore self-determination theory (SDT). SDT is a macrotheory of human motivation that recognizes human behavior as result of both psychological states of mind, as well as the social contexts in which humans act. All human behavior is situated in a larger social context that holds specific values, beliefs, and norms. Social contexts also serve to support or undermine individuals' three basic psychological needs of autonomy, competence, and relatedness. An individual's sense of autonomy refers to his/her need to feel like his/her behaviors arise from the self and are not controlled by someone outside the self (Deci, Koestner, & Ryan, 2001; Deci & Ryan, 1990; Ryan & Deci, 2002). A need for competence refers to a person's need to feel as if he/she has the ability to accomplish tasks (Deci & Ryan, 1990; Ryan & Deci, 2002). A need for relatedness refers to a person's need to feel as if he/she belongs in a social group and his/her contributions to the group are valued (Deci & Ryan, 1990; Ryan & Deci, 2002). When a social context fulfills these three basic psychological needs for a particular person, he/she feels motivated toward behaviors that are valued in that social context (Deci & Ryan, 1990). The degree to which the three basic psychological needs are fulfilled within a social context roughly correlates to the quality of motivation the individual experiences toward behaviors that are valued in that context. Motivation occurs on a continuum in which self-determination is the highest quality of all motivational types (Deci & Ryan, 1990; Ryan & Deci, 2002).

Self-determination is the highest quality of all the motivational types because ample evidence indicates that self-determined behaviors are long-lasting and continue even if they become more difficult to perform (Deci, Ryan, & Koestner, 2001; Ryan & Deci, 2002). Outside of EE settings, Pelletier (2002) and colleagues (Green-Demers, Pelletier, & Ménard, 1997; Pelletier et al., 1998) have demonstrated this applies to pro-environmental behaviors. Self-determination occurs when a person performs a behavior because it is pleasurable in its own right or when the behavior is fully integrated into the person's personality, so that if he/she did not do the behavior, he/she would not feel true to him/herself (Ryan & Deci, 2002). Such behavioral integration occurs for behaviors that are valued in social contexts in which the three basic psychological needs are fulfilled (Deci & Ryan, 1990). The integration occurs to the extent that they are no longer perceived as outside influences but rather arising from the self (Deci & Ryan, 1990).

Therefore, SDT indicates that social contexts that value pro-environmental behaviors while simultaneously fulfilling the three basic psychological needs will foster environmental self-determination, which is an impetus toward pro-environmental behaviors that results from either the pleasure derived from performing the behavior or the behavior being integrated into one's identity. So environmental educators should ask themselves: How do we generate a social context in our classrooms that both values pro-environmental behaviors and fulfills students' basic psychological needs so that such behaviors do become integral parts of their personality? Darner (2009) proposed several curricular features that are likely to do so, which are summarized here.

In order to support students' sense of autonomy in an environmental education classroom, Darner (2009) suggests offering choices to students about which environmental issues to investigate, as well as compelling them to generate plausible environmental solutions to those problems so that they feel environmental actions arise from the self, rather than from pressure from a teacher or other community member telling them what environmental behaviors they should be performing. Competence may be supported by posing optimally challenging situations to students that both make use of and sophisticate their scientific conceptions that relate to environmental problems. By engaging in such problems and constructing sophisticated conceptions of scientific principles and phenomena, students realize they possess the cognitive tools and are capable of solving environmental problems. Finally, to support students' sense of relatedness, educators can incorporate resources from the students' communities into the curriculum. This can be accomplished by using local environmental problems as case studies that present students with optimally challenging situations in the classroom. Similarly, students can be given assignments to interview family or community members about a local environmental problem. The goal in these curricular elements is to incorporate into the environmental education classroom those communities that likely already support students' sense of relatedness so that need satisfaction extends into the classroom.

Although these proposed curricular features are informative, they are speculative. Darner (2011) presented preliminary empirical evidence that an SDT-informed curriculum can produce measurable student outcomes in the form of decreased environmental amotivation (i.e., lack of motivation), but there was no direct examination of the effects of specific instructional features incorporated into the SDT-guided curriculum. This study aims to identify those curricular features that *students* find to be supportive of their three basic psychological needs. The goal is to use students' comments about need satisfaction while engaged in a problem-based life sciences course in order to generate hypotheses about specific elements of their classroom that support need satisfaction.

Methods

Research Setting

This study took place in a community college located in downtown San Diego, California that serves approximately 15,000 students (SDCC, 2004) in a section of *Biology 101: Issues in Environmental Biology* that was taught from an approach informed by SDT, as recommended by Darner (2009). Biology 101 is an introductory course for non-majors and is transferable to four-year institutions as a laboratory science credit. The course has both classroom and laboratory components. The lecture portion of the course involved problem-solving activities, whole class and small group discussions, and limited lecture. Three general phases comprised each curricular unit. In the first phase, the scientific and social aspects of a new issue was introduced by looking at the environmental issue through an everyday resource, such as a local newspaper article, interviews of community members, guest speakers from the community, or a field trip. The introduction concluded with a summarizing whole class discussion. The introduction was followed by engaging in a problem set (Darner, 2007). For each problem, student groups were given a prompt asking them to consider and discuss a situation and devise a solution or explanation for the phenomenon being addressed by the problem. Student groups would then share their explanations with the class in a whole class discussion, using large dry-erase boards that each group was provided. This process was repeated several times, depending on the particular problem set. Each problem set concluded with a general conclusion that was integrated into the final phase of the unit. To conclude each unit, both scientific and social aspects of the problem were addressed in a Socratic-style (i.e., question-driven) lecture in which students were compelled to reflect on the problem-solving activity. Assessment was accomplished through five exams, laboratory worksheets and homework, reflection writing, a group project, and participation in class discussions.

Students performed both classroom and laboratory activities in the same groups, which were determined at the beginning of the semester through the use of the 15-item New Ecological Paradigm (NEP; Dunlap et al., 2000). This instrument measures a person's pro-environmental orientation (or lack thereof). Heterogeneous groups of 3-4 students were formed according to responses on the NEP. This was done to attempt to avoid having a group(s) that only contained students who do not care about the environment and the issues addressed in the course. Meg, Carol, and Juan (pseudonyms) comprised the participant group. This group was chosen based on their willingness to participate during the first week of class, high attendance and minimal tardiness during the first two weeks of the course, and availability to participate in interviews immediately after class.

During every class session, beginning on the fourth session, a video camera was set up to record the participant group, while an additional camera recorded the entire class. All three students in the group were interviewed three times throughout the semester; each interview occurred following a class period in which one of the above problem sets was addressed. The interviews were stimulated-recall interviews, meaning that the interviewer and participant had access to the recording of the problem-solving activity during the interview, so that specifics of the activity could be isolated during the interview. Two trained science education colleagues conducted the interviews. Because I was the instructor in the course, it would have been ethically problematic for me to conduct the interviews before submitting their grades.

I conducted a one-hour interviewer training session that focused on informing the interviewers about the research goals, important elements of SDT, and the specific research questions. As I described each item of the interview protocol (Darner, 2007), I explained to the interviewers what information I was intending to decipher from the item. They were free to ask questions throughout the meeting, and we negotiated meaning until we felt we had reached intersubjectivity regarding their role in the research. I also provided logistical information, such as how to get to our classroom, where to park, and how to work the cameras. After training the interviewers, I gave the interviewers a course schedule, hard and electronic copies of the interview protocol, and contact information for the students and each other. The interviews were arranged separately between the participants and the interviewers. While the intention was that I be blind to the interview days, I was able to predict which days an interview would take place by considering the number of remaining interviews and the number of remaining days in the semester. Before each interview, I noted the time during which the problem-solving activity took place and located it on the videotape after class so the recording was ready for the interview. On the days that the interviewer and participant arranged, the interviewer arrived near the end of class, met with the participant, and conducted a 20- to 45-minute interview using the recording I had queued up. The interview itself was also video recorded. Although participants were interviewed individually, they consistently worked with each other over the course of the semester. Therefore, these were not three independently operating students in the course, but rather three different accounts of group activities.

There was one interview following each of the problem sets, with three exceptions. First, since the Western and Arroyo Toads problem occurred across three class periods, all three students were interviewed about this problem. Second, on the day that the participant group was scheduled to do their group presentation on human population growth, the projector that they intended to use was not working; Juan, who was interviewed that day, was unable to engage in the scheduled problem set because he was trouble-shooting the projector problem. Therefore, he was instead interviewed about his project on human population growth. The third and final exception is in the case of Baja Rodents. This problem took place on the same day that the Western and Arroyo Toads problem was wrapped up, so the interview addressed the conclusion of that problem.

After I had transcribed all interviews from throughout the semester, I open-coded (Strauss, 1987) transcriptions from interviews according to students' remarks related to the satisfaction or undermining of their basic psychological needs. I then axial-coded (Strauss, 1987) students' comments to identify which classroom features seemed to support or undermine their basic psychological needs. This resulted in a list of instructional features that seemed to support or undermine the satisfaction of students' basic psychological needs. As I analyzed students' interviews, supporting evidence for each item on this list of instructional features accumulated, as did additional items on the list. The substantial amount of time required to conduct this qualitative analysis was why only three participants were observed. However, the purpose of this grounded analysis was to produce a conjectured model whose primary purpose is not to generalize, as is the case with experimental methods (Corbin & Strauss 2008). Rather, this model arising from grounded analysis is better regarded as hypotheses based on deep observation that can be operationalized to be further tested (e.g., experimentally) for generalization.

Results

Seven features of the environmental education classroom were inferred to be relevant toward the support or undermining of students' basic psychological needs, as they relate to environmental self-determination. These features are referred to as: *curricular interconnectivity, conceptualization problem sets*, *instructional guidance*, *socio-scientific integration* throughout the curriculum, *student-guided lecture*, *cohesive group dynamic*, and *the "anything-goes" norm*. Each of these will be explained in turn.

Curricular Interconnectivity

A type of curricular design emerged from students' comments about what was supportive of their basic psychological needs. I call this type of design "curricular interconnectivity," which is when there are consistent themes throughout a unit so as to provide students multiple experiences to draw upon as they engage in environmental problem-solving. This feature first emerged from Meg's first interview following the *American Robins* problem. Meg provided an account of how she thought the problem fit into the larger scheme of both the class and humans' role in global warming by stating,

> *When we did the biomes and stuff we did a lot of the migration and then also we're learning about the energy forms. So this kind of relates to it because the migration patterns are all messed up with a lot of the energy we use … and then we're talking about global warming as an effect of some of the fossil fuels burning, so this kind of went with everything because the global warming is causing the spring to arrive earlier.*

Although this utterance does not seem to offer much in the way of explanation, Meg cited several important aspects of the curriculum. Prior to the day on which this interview took place, each student group was asked to briefly describe to the class a threat to a biome. Meg and her group discussed how oil drilling threatens the Arctic tundra. In their presentation, they cited how oil pipelines impede animal migrations, causing reproductive cycles to be disrupted. During the class period in which the *American Robins* problem occurred, we also constructed energy chains that portrayed how humans use energy from the sun. Given this history, Meg's comment begins to make sense. The problem seemed to be important to her because it fit within the context of how global warming was being addressed in the course (Figure 1). When asked what helped her group devise a solution to the American Robins problem, she cited instructional guidance, to be discussed later, and "just like prior knowledge of the global warming and then knowing what we had already learned about what could be like the bad effects of screwing up someone's migration." In other words, the *American Robins* problem included several other elements in the course, such as global warming and migration disruptions, and Meg was able to draw on each of these, which likely allowed her to feel competent about effectively solving the problem. Meg's account of the *American Robins* problem exemplifies curricular interconnectivity.

Conceptualization Problem Sets

Woven into the curriculum for this course was what I refer to as conceptualization problem sets. These are problems that have a specific structure and are intended to activate students' scientific understanding. I define students' scientific understanding as the collection of scientific concepts and the relations between concepts, but when this understanding is used to solve environmental problems, their understanding is conceptualized in the particular context of the problem. In other words, conceptualization is when their understanding is put into action in the context of a problem.

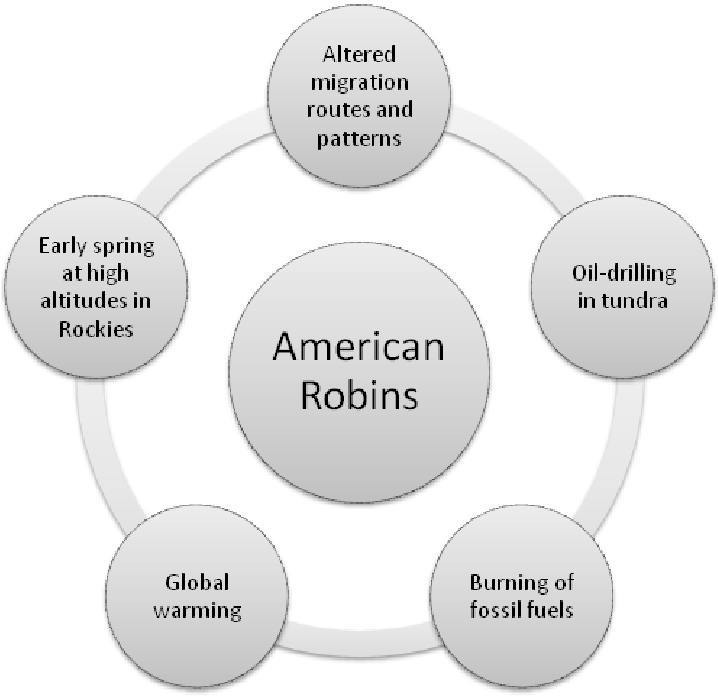

Figure 1. A depiction of how the American Robins problem was situated in the interconnected curriculum, which Meg used to explain why the problem was important to her

In this study, I claim that this mobilization of scientific understanding helps to satisfy students' basic psychological needs. This claim is supported by several of the participant group members' comments. For example, when the interviewer asked Juan during his second interview if there was anything else he would like to say about the problem or the discussion he and his group had, he stated, "Well … it was really interesting to me, basically because the learning, the learning is really interesting in this lab, basically … solving problems and I think I'm learning about different species and I'm being able to many times explain other people." His references to educating other people and solving problems indicate that the act of solving problems likely supports Juan's desire to educate others, which thereby supports his competence satisfaction. In their interviews, participant group members cited two aspects of the conceptualization problem sets that likely supported their basic psychological needs. I have named these aspects the collective construction of ideas and optimal complexity. Each of these will be further discussed.

Collective Construction of Ideas

In his first interview, the interviewer asked Juan how he and his group went about solving the *Colorado River Water Pollution* problem, and he stated, "We kind of come up with a different answer and then compare and then maybe get to one, just single solution." After the interviewer misunderstood his explanation as they choose the best solution from those that are put forth from each student, he clarified, "We actually … we kind of like mix it together to just make one single idea." In other words, Juan describes the collective construction of ideas, rather than simply choosing the best idea from individual students, and he cited this type of knowledge construction (i.e., "mix[ing] it together to make one single idea") as a factor allowing his group to devise a solution to the problem. Once this feature was established based on data from Juan's first interview, I returned to Carol and Meg's interviews in search of further evidence. In her second interview, Carol pointed to how Meg was able to remind her of which toad species made the call so that she could continue to engage in the problem. In her first interview, Meg stated that their group comes to an agreement by "pull[ing] pieces from everybody's idea," and in her final interview, she described how each individual is able to contribute to the collective construction of ideas when she stated, "When you read it you don't necessarily soak up all the information so the three of us each reading the problem, and then we each had a different intake like in one problem." I interpret these statements to mean that individual students are attuned to different aspects of the problem, so by working together, they can collectively construct solutions that draw upon each student's perspective. Collective construction of ideas, however, does not occur in all problem sets. In order for ideas to be collectively constructed during group discussion, the problems have to be of optimal complexity, which will be discussed next.

Optimal Complexity

When Meg was interviewed about the *Western and Arroyo Toads* problem, she commented that because she and her group mates had little prior knowledge regarding the problem, they "had a consensus from the beginning." She felt like she had more to contribute when the problems were more complicated because she and her group mates "all have different opinions and … have to share information to back up [their] individual opinion[s]." This depiction of conceptualization problem sets, when they are sufficiently complicated to generate discussion but still draw upon prior knowledge constructed while engaged in an interconnected curriculum, highlights what it means for a problem to be optimally complex. I also found evidence supporting the need for optimal complexity in Juan's second interview when he describes how he and Carol approached the *Western and Arroyo Toads* problem on the day when Meg was absent: "We kind of didn't discuss it that much, this answer, we just came up to the same idea." Alternatively, Juan tried to describe during his first interview what he experienced when the problem was of optimal complexity. He said, "I think that just the fact that by solving these kind of problems, I kind of use more my … I don't know … my thinking or my … what can be the word for it … critical thinking, I guess … Sometimes it's kind of hard, the problems, but sometimes they're just good enough." In this comment, Juan seems to agree with my claim that learning is different when scientific understanding is conceptualized (i.e., "by solving these kind of problems"), and a problem's level of difficulty is of optimal complexity (i.e., "just good enough").

Instructional Guidance

Every instructor attempts to help his/her students in some way, but participant group members referred to the help that I offered students while problem-solving as supportive of their basic psychological needs. This first emerged in the data during Meg's interview following the *American Robins* problem. She stated, "She came over and kind of pointed us in the right direction," and later in the same interview, she used the word "encouragement" to describe the help I gave her. It is important to note that as a general rule I did not simply give students answers to problems. I consider this different than what is offered in traditionally taught courses (Lord, 1999; Travis & Lord, 2004) in that I attempted to guide students as they constructed their own solutions, rather than giving the actual solutions. It is plausible that Meg cited the type of help I offered because it supported her needs for competence and autonomy. This is because if students construct their own environmental solutions, they would come to feel competent about their ability to do so, and they would not feel coerced into solving environmental problems or that solutions can only come from experts or positions of authority.

There was one instance, however, in which I did give an answer, and Juan found that to be especially satisfying. The *Western and Arroyo Toads* problem was addressed for three consecutive class periods during which several discussions took place about the meaning of biological fitness, the importance of fertility and sterility, and the consequences of hybridization. Juan's second interview took place following the second day of the *Western and Arroyo Toads* problem, at the end of which I resolved a lively discussion between two camps of students who were discussing whether biological fitness referred to physical fitness or something involved with reproduction. When asked what his favorite part of the class period was, he commented it was, "at the very end, when she gave us the answer and then we kind of understand it better and then well, we basically understand the idea or the whole problem that we started last week in coming to the conclusion." He later commented that my "giving them the answer" was when I told them that fitness, in biology, is one's ability to pass on one's genes to future generations, which resolved the dispute between the two camps of students. It seems that this provided Juan closure that he had been seeking for several days, which is why it was satisfying to him. It is unclear which basic psychological need this supported, but his reference to understanding "the idea or the whole problem" indicates that it likely supported his sense of competence. In most cases, simply giving students answers would likely undermine their sense of autonomy and competence (Reeve, 2002). This situation was different in that Juan seemed to feel like he had been involved in the knowledge construction up until the point that I provided the definition to them (i.e., "we understand the idea or the whole problem that we started last week"). From a pedagogical standpoint, my goal for waiting so long to give them the biological definition of fitness was to give the students an opportunity to distinguish the "biological fitness is physical fitness" concept from the scientific concept, only after which I would provide the definition. Juan's comments indicate that this not only helped him construct a more desirable concept of biological fitness, but it also supported his basic psychological needs.

Socio-scientific Integration

As I was analyzing the interview transcripts, I encountered numerous instances when students referenced social elements in the importance of their learning. For example, all three students at one time mentioned the importance of "real-life" connections. As these references accumulated, I decided I needed a way to encapsulate the social elements to which students were referring, which is why I devised the term socio-scientific integration. Socio-scientific integration is the inclusion of social elements of environmental problems in the environmental biology curriculum so that problem situations addressed are more authentic to the environmental issues students are likely to encounter outside of the course.

Initial evidence supporting the importance of socio-scientific integration was offered in Meg's first interview. Meg explained that if someone outside of the course were to approach her to discuss an environmental problem, she would be interested in the problem because "that shows that they're interested in it too, and if enough people get interested … then maybe there will be like changes." This indicates that in order for the environmental problem to be meaningful to Meg, it must be solvable given the larger social context. While addressing the problem in class, the social context is school, in which the norm is to solve a problem if it is assigned by an instructor, regardless if a student is interested in the problem. Meg, however, distinguished the school context from the out-of-school context when she said that, "if someone came up to me and was talking to me about it, then that shows that they're *interested*" (emphasis added). In other words, in order for Meg to feel that she can effectively solve environmental problems, others outside of school need to be interested in solving it as well. This indicates that in order for her to feel competent in solving environmental problems, her need for relatedness must first be satisfied in an out-of-school context that values environmental solutions. Theoretically, this could be accomplished by simultaneously integrating social groups that value pro-environmental behaviors and social groups to which students already belong, such as family, into the coursework through field trips, guest speakers, newspaper articles, and interviews of community members. This would help to connect students like Meg to social groups who are interested in solving environmental problems outside of the school context.

Further evidence supporting socio-scientific integration was given in Meg's interview following the *Western and Arroyo Toads* problem. She commented that her favorite part of this class period was when the pet trade was discussed, which gives insight into what satisfies Meg's need for relatedness. The pet trade is a social system that has ecological implications. Thus, more socio-scientific integration in the *Western and Arroyo Toads* problem would likely have been satisfying regarding Meg's need for relatedness, in addition to her need for competence. The importance of socio-scientific integration regarding satisfaction of students' need for relatedness is further evidenced by Meg's comments at the end of her second interview when she states that generally, the problems help "because [they] connect it to real life." She elaborated that this is also accomplished via our field trips, and this sentiment was echoed in her third interview when she stated, "The problems and stuff that we did and the field trips also helped because it showed you in real life." Similarly, Carol indicated a connection between the problems and everyday situations was important to her in her interview following the *Average Joe* problem. The item she received during that problem was to decide between paper or plastic bags at the grocery store. She explained to the interviewer, "It's funny [be]cause the same question happened to me when I went to Trader Joe's … So I'm thinking about it, 'So okay what would be better for the environment.'" Although she does not explicitly reference how receiving this item made her feel, the fact that she asked herself at the store what would be better for the environment indicates that she likely felt self-determined toward a pro-environmental behavior, which would necessitate satisfaction of basic psychological needs.

Carol's comments from her third interview further support the importance of social groups such as family. Carol mentioned her boyfriend and how "he already knows" how to recycle because "his family is into recycling and stuff." She explained why she did not know: "When I was growing up, we were never told to recycle anything. We threw everything away … We were never taught about the environment in school, at least I don't remember. We were taught about car pollution and stuff like that but nothing about recycling." Carol's comments indicate that recycling is likely a cultural behavior in which only certain groups participate, and the school culture of which she was a part did not value this behavior, even though they learned about environmental issues such as pollution. Her discussion with the interviewer throughout her third interview indicates that she is becoming acculturated into a social group that values pro-environmental behaviors, which includes her boyfriend. She explains how this has supported her sense of competence regarding environmental problems: "When I see something or when I read something or when I hear something over the news, I actually think about it, whereas before I'd just like turn the channel. (laughs) It was boring … No, now that I have the information, I can actually think about it." Becoming a part of social group that values pro-environmental behaviors, such as recycling, also likely supports Carol's sense of relatedness, enabling her to better inform herself about solving environmental problems. So this is the second instance in which we see that satisfaction of relatedness is a prerequisite to competence satisfaction.

A final piece of evidence supporting socio-scientific integration arose from Meg's final interview following the *Environmental Careers* task, after which she was particularly excited about looking into Sonoma State University's Environment and Education program. She stated, "I just basically liked the careers part of it because I always had this picture that if you're majoring in some sort of science, you're going to be stuck in a lab, like dissecting animals or doing something boring … like with a bunch of old people with glasses. I had this typical stereotype, so this kind of opened your eyes to all the different things you could do. When we had guest speakers come in and when we were like interested in their jobs, she told us like what kind of degrees you want to get." Here Meg offers evidence that her preconception of scientists had prevented her from engaging in science before this course. By integrating social elements into the course, her conception was changed, and she left this class period with the intention of exploring a science-related degree program, thereby indicating her sense of competence had been supported. Furthermore, she cited the integration of guest speakers into the curriculum as a factor in changing her conception of scientists. So while field trips, guest speakers, and family interviews were incorporated into the curriculum of this course for theoretical reasons, the participant group members' comments provide empirical evidence that these socio-scientific features indeed supported their basic psychological needs so that they became more self-determined toward pro-environmental behaviors, such as pursuing an environment-related career.

Student-guided Lecture

Importance of the student-guided lecture initially emerged from Meg's first interview. Although it can have numerous definitions, student-guided lecture, as I define it in this study, is a whole-class discussion in which pertinent information comes from the students, rather than the instructor, and students are granted the opportunity to direct the discussion within parameters set by the instructor. In the student-guided lecture that Meg references in her first interview, the material addressed was the various ways that humans use energy from the sun. From a previous activity, the students knew of the various ways, but my goal of this discussion was to construct energy chains for each use and follow the energy from the sun to how it is used by humans. In her interview following this class period, Meg explained that her favorite part of class was this lecture about how humans use energy from the sun. When asked why this was her favorite part, Meg stated, "[Be]cause I like feeling like I am knowing what she is talking about." Later she also states, "It's cool when she gives notes … and stuff in my head is clicking," and "I like when I know something and I'm not just sitting here like confused … trying to figure out what's going on." These comments indicate that this discussion was her favorite part because it likely satisfied her need for competence. She then described how I led the discussion: "She'll say 'Okay, which one do you guys want to talk about?' and so the first one we picked was fossil fuels, so then we tell her like what to write." In other words, the students were allowed to take some level of ownership over the direction of the lecture within the parameters that I had set. As they provided what to include in the energy chains, I constructed them on the board and asked Socratic questions of the students when they omitted information. I provided the information myself only as a last resort when students were unable to provide important elements to the discussion. I also allowed them to choose which energy chains would be constructed in which order, although I had determined which chains would be constructed. Meg's comments indicated that this style supported her need for competence. Student-led lectures, however, likely support their need for autonomy as well because most of the important information arises from the students, not the instructor as an authority.

Cohesive Group Dynamics

The socio-contextual feature that I have labeled cohesive group dynamics actually refers to a collection of characteristics describing what members of the participant group referenced that seemed to support their basic psychological needs throughout the course. Meg described the first characteristic in her last interview when she explained why she is open to sharing her ideas in her group: "I think it's gotten better over the semester where we can each kind of say whatever we think and not worry about like 'Are these people going to think I'm a weirdo?' or 'Am I going to be taken seriously?'" Later she clarified the importance of staying with the same group throughout the whole course: "I also think that … it was good that Juan and Carol were my partners every day, that we didn't rotate around, because we got more comfortable with each other." Therefore, the first characteristic of the participant group that seemed to support their basic psychological needs was a consistent student group. Specifically, this feature likely supported their sense of relatedness because they came to feel a sense of belonging within their student group. Moreover, it also likely supported their sense of competence, as such ease with their group members allowed them to put forth ideas for solving problems that they would not have shared if they were to feel hindered by a lack of relatedness. It should be noted that I assembled heterogeneous groups according to their responses on an environmental attitudes questionnaire, so while Meg cited consistent groups as a supporting factor, the instructor should take the initiative to assemble the groups based on some theoretical grounds.

Meg also explained that she did not feel afraid to offer her ideas because she knew they would be taken seriously, which likely supported her basic psychological needs. Similarly, Carol and Juan both commented in all of their interviews that they felt their group mates took their contributions seriously. For example, in her final interview, Carol commented, “We listen to each other’s ideas and stuff without just disregarding right away.” While compelling students to take each others’ ideas seriously may be considered out of the instructor’s control, the instructor can assemble groups so that each group is composed of students of relatively equal status. Indeed, Meg’s comments indicated that she perceived her group mates having equal status. For example, in her final interview, Meg explained, “I think that each of us take each other’s opinions like equally. It’s not like my opinion is better than Carol or Juan’s but if my opinion is treated the same, it’s like as if it was their own opinion so it’s just equal.” Later she reiterated, “It’s not like one of us is smarter than the other.” Upon my return to Meg’s earlier interviews, I inferred further evidence for this characteristic of their group. She commented, “It’s different with every problem. One of us could be like knowing it all and then another one of us on the next day might know a bunch of other stuff.” This comment not only highlights an added benefit of the conceptualization problem sets, but it also gives insight into what she meant when she stated that none of her group members are smarter than any of the others. The notion of equal status also arose in Meg’s first interview when she explained that everyone’s ideas get “a fair shot.”

A final characteristic of this group is that it contained one member whom all members perceived as the questioner. Carol described her role in her second interview: “I’m usually the type that … just throws things out there, even if it’s wrong or right or even if someone thinks something is right, I’m always the one to be looking at it like, ‘Wait a minute, you know what if, what if this, what if that?’” Carol agreed with the interviewer when she asked if Carol felt if the questions she posed helped her group to come to consensus, indicating that playing this role likely supports her sense of competence. Similarly, in her interview following the *Channel Island Foxes* problem, she explained the video to the interviewer by stating, “So I’m just trying to throw something out there so we can just start talking about it.” Meg described Carol’s tendency to “throw things out there” when she stated in her final interview, “Some of us are more shy than other so like if Juan knew the answer in his head, he might not necessarily spit it out, but if Carol knows it, she’s just going to blurt it out right away.” In his first interview, Juan described Carol’s tendency to question their claims when he said, “She’s the kind of girl that we say something and she starts thinking ‘What if? What if?’” Juan explained that in the case of the *Colorado River Water Pollution* problem, Carol’s persistence led them to seek help from the instructor. It seems that having a questioner in the group helped them for two reasons. First, Carol’s tendency to “throw stuff out there” generates discussion in the group, a vital factor in supporting students’ basic psychological needs, as discussed in the section on conceptualization problem sets. Juan evidenced this in his first interview when he described how he contributes to the group. He stated, “I kind of listen to them when they start with the conversation and then I … start thinking about their opinions and then agree or disagree or say something or add to it.” Second, the discussion that is generated by Carol’s questions led students to feel more competent in solving problems. Juan also supported this notion in his first interview when the interviewer asked, “Do you think they ever change their opinions because of what you say?” He responded, “A little bit … When I … add to it, maybe they will ask another question just to make sure their idea is right or wrong … They try to make sure that their thoughts are right, maybe having more people agreeing with the idea." In other words, by Carol and Meg's continuing to ask questions, Juan seemed to think they approached a more correct answer, which likely supported how competent he felt in solving the problem. Additionally, Juan implies that each member of his group has a role to play. Carol is the questioner; Meg responds; and Juan agrees or disagrees to provide a level of confidence to their solutions. By having a specific role to play in the group, the students' need for relatedness is also likely satisfied.

The "Anything-goes" Norm

The "anything-goes" norm describes the collective belief that any comment or question, no matter how tangential or unrelated to the problem at hand, could be asked during the discussion. I believe this norm developed because of my openness to student participation in during lectures and encouragement to their asking questions. Initial evidence for the development of this norm came from Meg's data. In her first interview, she stated, "When we're talking in lecture I always get these random questions like don't really pertain to anything … but I don't usually ask them just like I don't want to get off on a tangent and direct the class in a whole different direction." Later she added, "That would take the class in a whole different direction [be]cause when one person says something random, … it's fun, be we get off from where we're trying to go." She seemed to find this norm annoying because she wanted to stay on task. This issue arose in this interview because during the discussion about humans' energy uses, she wanted to ask about windmills she had seen in the area, but she refrained from doing so for the reason explained above. Meg also commented that she and Carol were wondering if the robins that survived the period without food one year would remember the following year to wait longer to migrate to higher altitudes. Yet, she did not ask this question because "It didn't really pertain to anything. It didn't really matter. It was just completely off the subject." Given her and others' anthropomorphization of the robins and other animals throughout the course, I would have welcomed this question, and an answer to it would have likely supported her feelings of competence in solving the problem. The development of the "anything-goes" norm, however, prevented her from asking these questions, the answers to which would have likely supported her basic psychological needs. Therefore, the development of this norm seemed to undermine satisfaction of students' basic psychological needs.

Discussion

In this study, I asked what classroom features do students cite when they indicate that their basic psychological needs are being fulfilled or undermined. Students consistently cited seven features of the instructional environment as relevant to their basic psychological needs. It is important to note that the fulfillment or undermining of students' basic psychological needs are cognitive events and therefore cannot be directly observed, despite availability of video-recorded data. These findings rely on student a report of their feelings of fulfilled or thwarted needs, and their reports, rather than researchers' conjectures about their need fulfillment, is strength of this research. However, caution should always be taken when relying on student reports because such feelings may be subconscious or implicit to the student. Therefore, my claims about the factors that support or undermine students' environmental self-determination hold hypothesis status, and further research is needed quantitatively test these hypotheses, as well as to elucidate how each factor contributes to the fulfillment of one or more of students' basic psychological needs. Nevertheless, many of these features are supported by a literature base, which will be discussed here.

I inferred curricular interconnectivity, which I define as the inclusion of consistent themes throughout a unit so as to provide students multiple experiences to draw upon as they engage in environmental problem-solving, to be supportive of students' sense of competence. The notion of novelty space (Orion & Hofstein, 1994) provides insight into why an interconnected curriculum might support students' learning and basic psychological needs. Orion and Hofstein (1994) define novelty space as the combined effect of cognitive, psychological, and physical aspects of a novel experience that undermines students' ability to learn during that experience. The notion is applied to field-based learning, such as during field trips (Hofstein & Kesner, 2006; Kean & Enochs, 2001; Orion & Hofstein, 1994; Riggs, 2004). Nevertheless, the idea that greater familiarity in the learning experience correlates with better learning could apply to any setting, not only learning in the field. In this study, when students' novelty space was reduced through student-guided lecture, field trips, and guest speakers, their learning during in-class problem-solving was supported, which students in turn cited as supportive to their basic psychological needs. Although the novelty space construct has thus far been applied to field-based learning, the importance of curricular interconnectivity in my study indicates that it is also relevant to problem-based learning. Orion (1993) suggests that a pre-field trip orientation can reduce students' novelty space. If an in-class problem set takes the place of a field trip in my fresh application of the novelty space construct, then it would be wise to orient students to the problem set. Therefore, the connected elements of the curriculum, such as a guest speaker, would precede in-class problem-solving. These instructional adaptations are demonstrated later in a learning cycle that I put forth in the *Instructional Implications*.

Socio-scientific integration is another feature of the instructional environment that students cited as supportive to their basic psychological needs. I defined this construct as the inclusion of social elements of environmental problems in the science curriculum so that problem situations addressed in the course are more authentic to the environmental issues students are likely to encounter outside of the course. Social elements of environmental problems can be included in the curriculum in the form of news reports, newspaper articles, field trips, interviews of family or community members, guest speakers, and assignments that ask students to evaluate the claims of a social figure, such as a politician. Darner (2007) indicates a consistent positive correlation between relatedness support in the classroom, students' relatedness fulfillment, and environmental self-determination. By including social elements of environmental problems, students' need for relatedness is likely to be better supported in the classroom. Additionally, Meg explained that if someone were to approach her outside of class about an environmental problem, that would indicate to her that there are other people caring about the issue and it would thus be more solvable. These data from Meg indicate that fulfillment of one's sense of relatedness may provide a foundation for one's sense of competence. This is supported by the positive correlation between competence and relatedness that Darner (2007) observed. Thus, it seems that socio-scientific integration is especially relevant not only to students' sense of relatedness, but also to their sense of competence.

Andrew and Robottom (2001) make a recommendation that is similar to socio-scientific integration when they call for a contextualization of science instruction. Research investigating the relationships between students' conceptual knowledge and conceptions of nature of science on one hand, and their reasoning employed during argumentation and decision-making on the other, support Andrew and Robottom's (2001) and my suggestion. For instance, Sadler (2004a; 2004b) found that students generally do not consider the nature of scientific knowledge when evaluating the accuracy or reliability of information. Furthermore, the quality of their nature of science conceptions do not relate directly to their decision-making regarding socio-scientific issues (Bell & Lederman, 2003; Sadler, 2004a; Sadler, 2004b; Zeidler, et al., 2002). This is likely because students do not only refer to their content knowledge in making a socio-scientific decision and/or argument (Sadler, 2004a; Sadler, 2005; Sadler & Zeidler, 2005), but they also take into account their own emotions, value judgments, and/or personal investment in the socio-scientific issue (Hogan, 2002; Sadler, 2004a; Sadler, 2004b; Sadler & Zeidler, 2005; Zeidler, *et al.*, 2002). Sadler and Zeidler (2005) attribute this observation to three types of reasoning that students use when making decisions about socio-scientific issues: rationalistic, emotive, and intuitive. In making decisions and constructing arguments regarding socio-scientific issues, students use a combination of all three of these reasoning types (Sadler & Zeidler, 2005). I raise this issue to point out that if we want students to make decisions that are informed by science, which is a well agreed upon component of scientific literacy (Laughksch, 1999), we must consider all of what students use to make decisions. Because a situation that calls for rationalistic reasoning alone is unlike any decision-making context students are likely to encounter in their lives, it is unreasonable to insist that in the science classroom students are only allowed to employ rationalistic reasoning. The alternative that I suggest, which invites authentic decision-making contexts into the classroom, would give instructors the opportunity to teach students to employ rationalistic, emotive, and intuitive reasoning appropriately. Further research is needed to guide instructors on how to do so, but insisting that students check their emotions at the door of the science classroom would insure failure in accomplishing the decision-making component of scientific literacy.

Another benefit of socio-scientific integration is the necessity for science curricula to evolve as decision-making contexts change. In today's world, environmental issues is the most important of these decision-making contexts, as evidenced by the magnitude of the global environmental dilemma. Huckle (1993) made this argument when he stated that environmental problems and education are anchored "firmly within the changing social structures and processes which shape the combined and uneven development of people, environments and societies around the world (p. 43)." Hodson (2003) claims that the disconnection between science and society in current science curricula does not allow science education to meet the needs of today's citizenry, including the need to ameliorate the global environmental dilemma. Furthermore, democracy is increasingly purported to be the key to end a host of international problems such as war and poverty. Citizens who are well equipped to make informed decisions and participate in policy formation support the success of democracies (Hodson, 2003; Roth & Désautels, 2002; Roth & Lee, 2002; Wells & Claxton, 2002). However, if a democracy is going to exist in more than name only, citizens must not only become scientifically literate but politically literate as well (Hodson, 2003; Kolstø, 2001; Roth & Désautels, 2002; Roth & Lee, 2002). Citizen participation in policy-making is the cornerstone of democracies, yet students seldom develop the ability to engage in such participation regarding any issue, including environmental issues (Hodson, 2003). Therefore, several researchers have called for a contextualization of science education that allows students to develop understanding of everyday scientific and technological problems and empower them to work collectively in reaching solutions through socio-political action (Andrew & Robottom, 2001; Hodson, 2003). In fact, Gough (2008) argues that incorporating the realities of environmental problems into science curricula would enhance waning student engagement in the sciences. From my perspective, these views have already embraced the notion of socio-scientific integration. This study simply puts forth another likely benefit of such an approach, which is fulfillment of students' basic psychological needs so that self-determined environmental motivation is fostered.

A final potential benefit of socio-scientific integration is the valuing of students' cultural capital (Bourdieu, 1986). Perreira, Harris, and Lee's (2006) modern account of cultural capital is of particular relevance to socio-scientific integration as it was realized in my environmental biology course. They define cultural capital as "family-mediated values and outlooks that facilitate access to education" (Perreira, Harris, & Lee, 2006, p. 515). They draw attention to how families can support students' academic success by developing close, supportive relationships that facilitate communication (Perreira, Harris, & Lee, 2006). This was observed in the data from all three of the participant group members, each of whom described conversations with family members about the coursework and associated environmental issues. Socio-scientific integration can take advantage of this cultural capital by necessitating such communication with students' family members through assignments, such as interviewing family members about their ideas regarding a local environmental problem. Such an approach would likely support students' sense of relatedness both in the class and in their family as they solve environmental problems cooperatively.

A final and integral feature of the instructional environment that students indicated were supportive of their basic psychological needs was the conceptualization problem sets. These are so named because they provide students opportunity to mobilize their scientific understanding as they conceptualize environmental problems. These problems follow a specific format in which students receive a description of an environmental problem accompanied by an initial question or task (e.g., "How do you think X affects Y?" or "Construct a diagram …"). Student groups discuss, collectively construct their solutions, and a whole-class discussion follows. As the student groups are discussing their solutions, the instructor visits each student group to provide guidance as described earlier. During this phase, the instructor refrains from simply giving answers, as this robs students of the opportunity to grapple with the problem and devise their own solution. Not only would giving answers at this phase likely undermine students' sense of autonomy, but it would defeat the purpose of giving students the opportunity to conceptualize the problem using their own scientific understanding. During the whole-class discussion, the instructor asks for solutions from student groups and guides the collective construction of ideas toward the learning goal. Then another prompt is given that furthers engagement in the problem, and this process is repeated.

Deci and Ryan (1990) point out that in order for a situation to satisfy all three basic psychological needs, it needs to be an optimally challenging situation. Optimally challenging situations have three components (Deci & Ryan, 1990): the situation must disagree with one's cognitive structure or what I refer to in this paper as their scientific understanding, (b) the student must perceive the situation or problem as solvable, and (c) it must be encountered in a social situation that is supportive of the three basic psychological needs. Ideally, all conceptualization problem sets would constitute an optimally challenging situation for every student, but this is unlikely. This study, however, indicates that there are certain characteristics that make it more likely that a conceptualization problem set will constitute an optimally challenging situation. For example, in order for it to disagree with one's cognitive structure, it should be of optimal complexity, so that it disagrees with students' cognitive structure but still seems solvable to them. Similarly, in order for students to view the conceptualization problem set as solvable, it should be imbedded in an interconnected curriculum that provides multiple resources upon which to draw as they attempt to solve it. Additionally, socio-scientific integration, as discussed above, is likely to provide a social context that is supportive of students' basic psychological needs, and it is within this context that students engage in the conceptualization problem sets.

The fact that students engage in conceptualization problem sets in a student group also likely supports their basic psychological needs. Group problem-solving allows for the construction of zones of proximal development in which students develop desirable scientific understanding (Lemke, 2002; Vygotsky, 1978), which in turn supports their need for competence when solving environmental problems. Similarly, group problem-solving involves collaboration through which a learning community is developed (Claxton, 2002; Lemke, 2002; Wells & Claxton, 2002). Such a learning community in a science course is more likely to develop shared beliefs, values, and tools through which environmental solutions can be valued and achieved.

Instructional Implications

A host of teaching implications have emerged from this study, many of which have been alluded to already. In this section, I will synthesize these implications to gain perspective on what is likely to constitute a science course that fosters self-determined environmental motivation.

All three of the participant group members indicated that cohesive group dynamics supported their basic psychological needs, thereby implying that the assembly of student groups cannot be taken lightly. I used the New Ecological Paradigm (NEP; Dunlap et al., 2000) scale to assemble students of varying environmental attitudes. This seemed to work well, as evidenced by the group members repeated comments about how well they worked together. Due to their comments about how every group member contributed to the group relatively equally, it might also be wise to assemble groups not only according to an attitudinal scale, such as the NEP, but also a scale that measures scientific knowledge. Because the group members cited their relative equality as important, this scale could be used to assemble homogeneous student groups. A final recommendation is that student groups be constant throughout the course to help them develop a sense of belonging. It is important to remember, however, that these suggestions are based on students' ideas about what supported their basic psychological needs and may not reflect what actually helped them. Furthermore, this group was selected as the participant group partially because of their high attendance during the first two weeks of class; it is possible that groups whose members are often absent may not have such a cohesive experience, despite taking the measures described above.

I have devised a learning cycle (Figure 2) that integrates the numerous factors within a science classroom that I found to be relevant toward fostering students' self-determined environmental motivation. There are many ways in which these factors could be integrated into a science course; my suggested learning cycle is just one way this integration could occur.

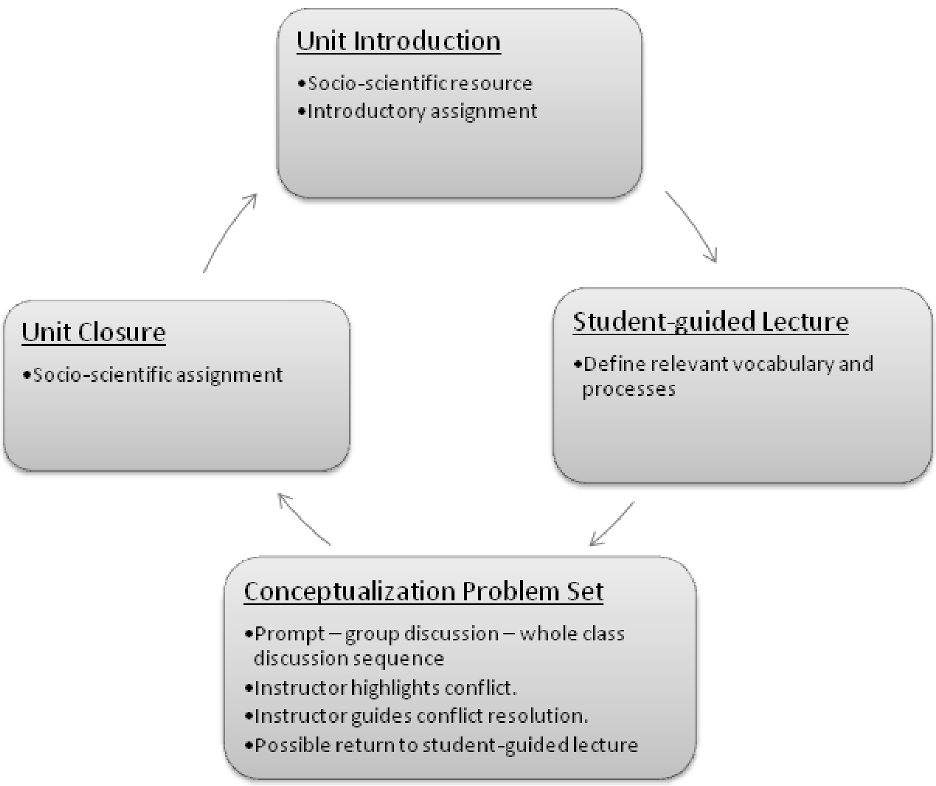

Figure 2. A possible learning cycle based on instructional implications of this study

According to my suggested learning cycle, the instructor begins a curricular unit by introducing the broad topic through a socio-scientific resource such as a field trip, guest speaker from the community, or news report. An assignment, such as a written reflection or online discussion board participation could accompany the introduction. A student-guided lecture follows the introduction in which relevant vocabulary and processes are defined. Engagement in a conceptualization problem set follows the student-guided lecture. The socio-scientific resource and lecture precede problem-solving in order to provide students numerous resources from which to draw as they engage with the conceptualization problem set. In other words, it better provides an interconnected curriculum that provides multiple representations of scientific concepts to students as they conceptualize the environmental problems they are asked to solve. The conceptualization problem set would follow the prompt-group discussion-whole class discussion sequence. During whole class discussions, the instructor highlights conflict that arises between content presented in the student-guided lecture and students' scientific conceptualizations of the problem. The instructor plays an important role during these whole class discussions because s/he is charged with the responsibility of guiding students as they resolve such conflict, which may involve a resurrection of the student-guided lecture. After the problem-solving session, which may take several days of the unit, the unit is closed with a socio-scientifically integrated assignment. Examples of such an activity include participating in an online discussion board, critically analyzing the claims of a political or activist group, or designing and performing an inquiry-based laboratory experiment.

Conclusion

This study resulted in numerous hypothesized features that likely foster environmental self-determination in a science course. These features include the use of conceptualization problem sets, an interconnected curriculum, and socio-scientific integration. Conceptualization problem sets allow students to mobilize their scientific understanding in powerful zones of proximal development that become established among group members. This supports students' feelings of competence by demonstrating their ability to solve real environmental problems. Reaching successful problem-solving as a group supports group members' sense of belonging in their group. And the open-endedness of the problem sets allow students choice, which supports their sense of autonomy, in how to approach the environmental problems. The interconnected curriculum provides students multiple representations of scientific concepts, thereby enhancing their scientific understanding and ability to solve environmental problems. In other words, such a curricular format supports students' sense of competence when solving environmental problems. Finally, socio-scientific integration in the curriculum supports students' sense of relatedness to each other, their communities, and environmentalism, because the curriculum explicitly highlights the environmental problems embedded in their local community. I have integrated these findings into a learning cycle, the effectiveness of which could serve as a topic of future research. Further exploration of the scientific knowledge and instructional features that lead to self-determined pro-environmental behavior is also needed to test these hypothesized features on a larger scale.

Acknowledgements

The author wishes to thank Alexander Chizhik for his guidance during this research and his feedback on early drafts of this article. The author is also grateful for her students' participation in the study.

References

Andrew, J., & Robottom, I. (2001). Science and ethics: Some issues for education. *Science Education*, 85, 769-780.

Bell, R.L. & Lederman, N.G. (2003). Understandings of the nature of science and decision making on science and technology based issues. *Science Education, 87*, 352-377.

Bourdieu, P. (1986). The forms of capital. In J.G. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241-258). New York, NY: Greenwood Press.

Claxton, G. (2002). Education for the learning age: A sociocultural approach to learning to learn. In G. Wells & G. Claxton (Eds.), *Learning for life in the 21st century* (pp. 19-33). Malden, MA: Blackwell Publishing.

Corbin, J. & Strauss, A. (2008). *Basics of Qualitative Research*, 3rd ed. Los Angeles: Sage Publications.

Darner, R. (2007). Supporting students' self-determined environmental motivation in a formal environmental education setting (doctoral dissertation). University of California, San Diego, San Diego, CA.

Darner, R. (2009). Self-determination theory as a guide to fostering environmental motivation. *Journal of Environmental Education, 40*(2), 39-49.

Darner, R. (2011). An empirical test of self-determination theory as a guide to fostering environmental motivation. *Environmental Education Research*. doi: 10.1080/13504622.2011.638739.

Deci, E. & Ryan, R. (1990). A motivational approach to self: Integration in personality. In R. Dienstbier (Ed.), *Nebraska Symposium on Motivation: Vol. 38. Perspectives on motivation* (pp. 237-288). Lincoln: University of Nebraska Press.

Deci, E.L., Koestner, R., & Ryan, R.M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research, 71*, 1-27.

Deci, E.L., Ryan, R.M., & Koestner, R. (2001). The pervasive negative effects of rewards on intrinsic motivation: Response to Cameron (2001). *Review of Educational Research, 71*, 43-51.

Dunlap, R.E., Van Liere, K.D., Mertig, A.G., & Jones, R.E. (2000). Measuring endorsement of the New Ecological Paradigm: A revised NEP scale. *Journal of Social Issues, 56*, 425-442.

Gough.A. (2008). Towards more effective learning for sustainability: Reconceptualising science education. *Transnational Curriculum Inquiry, 5*(1), 32-50.

Green-Demers, I., Pelletier, L., & Ménard, S. (1997). The impact of behavioral difficulty on the saliency of the association between self-determined motivation and environmental behaviors. *Canadian Journal of Behavioral Sciences, 29*, 157–166.

Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education, 25*, 645-670.

Hofstein, A. & Kesner, M. (2006). Industrial chemistry and school chemistry: Making chemistry studies more relevant. *International Journal of Science Education, 28*, 1017-1039.

Hogan, K. (2002). Small groups' ecological reasoning while making and environmental management decision. *Journal of Research in Science Teaching, 39*, 341-368.

Huckle, J. (1993). Environmental education and sustainability: A view from critical theory. In J. Fien (Ed.), *Environmental Education: A pathway to sustainability* (pp. 43-68). Melbourne, Australia: Deakin University.

Kean, W.F. & Enochs, L.G. (2001). Urban field geology for K-8 teachers. *Journal of Geoscience Education, 49*, 358-363.

Kolstø, S. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education, 85*, 291-310.

Laughksch, R.C. (1999). Scientific literacy: A conceptual overview. *Science Education, 84*, 71-94.

Lemke, J. (2002). Becoming a village: Education across lives. In G. Wells & G. Claxton (Eds.), *Learning for life in the 21st century* (pp. 34-45). Malden, MA: Blackwell Publishing.

Orion, N. (1993). A model for the development and implementation of field trips as an integral part of the science curriculum. *School Science and Mathematics, 93,* 325-331.

Orion, N. & Hofstein, A. (1994). Factors that influence learning during a scientific field trip in a natural environment. *Journal of Research in Science Teaching, 31,* 1097-1119.

Pelletier, L. (2002). A motivational analysis of self-determination for proenvironmental behaviors. In R. Ryan & E. Deci (Eds.), *Handbook of self-determination research* (pp. 205-232). Rochester, NY: University of Rochester Press.

Perreira, K.M., Harris, K.M., & Lee, D. (2006). Making it in America: High school completion by immigrant and native youth. *Demography, 43*, 511-536.

Riggs, E.M. (2004). Field-Based education and indigenous knowledge: Essential components of geoscience education for Native American communities. *Science Education, 89*, 296-313.

Roth, W. & Désautels, J. (2002). Science education as/for sociopolitical action: Charting the landscape. In W. Roth & J. Désautels (Eds.), *Science Education as/for Sociopolitical Action* (pp. 1-16). New York: Peter Lang.

Roth, W. & Lee, S. (2002). Breaking the spell: Science education for a free society. In W. Roth & J. Désautels (Eds.), *Science Education as/for Sociopolitical Action* (pp. 65-91). New York: Peter Lang.

Ryan, R., & Deci, E. (2002). Overview of self-determination theory: An organismic dialectical perspective. In R. Ryan & E. Deci (Eds.), *Handbook of Self-Determination Research* (pp. 3-33). Rochester, NY: University of Rochester Press.

Sadler, T.D. (2004a). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*, 513-536.

Sadler, T.D. (2004b). Student conceptualizations of the nature of science in response to a socioscientific issue. *International Journal of Science Education, 26*, 387-409.

Sadler, T.D. (2005). Evolutionary theory as a guide to socioscientific decision-making. *Journal of Biological Education, 39*, 68-72.

Sadler, T.D. & Ziedler, D.L. (2005). Pattern of informal reasoning in the context of socioscientific decision making. *Journal of Research in Science Teaching, 42*, 112-138.

Strauss, A.L. (1987). Codes and coding. In A.L. Strauss, *Qualitative analysis of social scientists* (pp. 55-81). Cambridge, MA: Cambridge University Press.

Wells, G. & Claxton, G. (2002). Introduction: Sociocultural perspectives on the future of education. In G. Wells & G. Claxton (Eds.), *Learning for life in the 21st century* (pp. 1-17). Malden, MA: Blackwell Publishing.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Zeidler, D.L., Walker, K.A., Ackett, W.A., & Simmons, M.L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education, 86*, 343-367.

Corresponding Author: Dr. Rebekka Darner, Illinois State University, School of Biological Sciences, Campus Box 4120, Normal, IL 61790-4120, USA. E-mail: rldarne@ilstu.edu

Please cite as: Darner, R. (2014). Influences on students' environmental self determination and implications for science curricula. *International Journal of Environmental and Science Education, 9*, 21-39. doi: 10.12973/ijese.2014.201a