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# מעורבות פעילה של תלמידי תיכון בפרויקט מדעי-חברתי בבית ספרם: התפתחות זהות במהלך פעולה

# High school students' engagement in a school-based socioscientific project: Development of identity in practice

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**Abstract**

This study explored the ways in which high-school students participate in a socioscientific project using identity research as an analytic lens. The social implications that evolve from negotiating socioscientific issues (SSI) allow for multiple connections to students' world views by associating science with moral aims and by linking social values to actions on science-related issues. For these reasons, dealing with SSIs allows students to web scientific concepts with their own personal world views and identities. Following situated learning theories, the construct of identity formation with relation to practice is suggested as an analytical lens to examine students' participation. The primary purpose of this study was thus to understand the ways in which students practiced and built their practice-linked identities through participation in a school-based socioscientific project. Additional emphasis was placed on students' willingness to participate in an action toward SSI resolution. The students in the examined project take an active effort in reducing malnutrition in underdeveloped countries by developing an affordable and efficient cultivation method for the cyanobacteria *Arthrospira* (Spirulina) as a dietary supplement. Data were gathered using several sources, including phenomenological interviews, observations and documents analysis to explore the narratives of two students (case studies). Data were analyzed using a hybrid process of inductive and deductive analyses. The analysis focused on identity resources that can support students' identity development in practice: having access to the domain, opportunities to take on integral roles, and opportunities for self-expression in the practice. Findings suggest that case study students were afforded deep engagement in practice as they found a connection between who they are and the project. Specifically, students had a wide access to the domain, mainly by being afforded rich and contextual experiences. These experiences appear to have also initiated and motivated students' willingness to take action in the context of global malnutrition. Students took up integral roles which mattered to them and to the practice as a whole and felt accountable to improve their skills in these roles. And finally, they had numerous opportunities for self-expression in practice, which were built upon significant ideational and relational resources. Students' narratives reveal how their ability to find a connection between their identities and the practice was generated through contextual and authentic experiences, which ultimately supported their deep engagement in the practice.

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## Introduction

Modern society is deeply influenced by science and technology (Latour, 2012). The pervasiveness of science on people's lives could be exemplified by the intense discussions in the public sphere that focus on issues such as climate change, access to clean water, food shortages, genetic modification and other critical issues that affect our society. These issues propose an inherent social significance because they involve one or more of cultural, ethical, moral, economic or political concerns (Zeidler, Sadler, Simmons, & Howes, 2005). Because of the central roles of both social and scientific elements in these issues, they have been termed *socioscientific issues* (abbreviated as SSI). It is not surprising then that present reform initiatives in science education call for increased attention to current, socially relevant scientific issues, as well as for broadening the conceptual definition of scientific literacy to reflect on the interactions between science and society (American Association for the Advancement of Science, 1989; American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). Science education has to expand to address these demands and to provide scientists, and non-scientists alike, with a broad scientific literacy that will reflect the knowledge, skills, and values necessary to engage with SSIs (Ariza, Abril, Quesada, & García, 2014).

As a result of the social implications of SSIs, these issues, in addition to being subjected to scientific rules, data, and theory, can also be subjected to social, economic, political and ethical considerations. For that reason, SSIs may offer multiple links to students' interests, values, and belief systems, which may assist students in creating their own unique paths to science learning (Zeidler et al., 2005). Exploring how students address such multifaceted issues highlights the necessity for a rich theoretical lens that takes into consideration the complex ways students negotiate and participate in SSIs (Sadler, 2009). In this context, an identity-based framework was suggested as an analytic lens to represent the complex dialectic and practices in which students engage as they negotiate and attempt to resolve SSIs (Sadler, 2009; Zeidler et al., 2005).

This study explores high-school students' participation in an SSI project using identity research as an analytic lens. Here, students participating in an existing SSI project in the Gymnasia Herzliya High School in Tel Aviv were examined. This project, named the 'Spirulina Project' by the students who take part in it, is aimed at optimizing the

growth conditions of the cyanobacteria *Arthrospira* (Spirulina) as a dietary supplement. Students who participate in the Spirulina project engage in authentic scientific practices: they ask research questions; they collect and analyze data, and they communicate their findings to the global and local community. In this thesis, I present a case study of two students, Yonatan and Karin (a pseudonym), who participated in the Spirulina project. The primary purpose of this study was to understand and make sense of the ways in these students came to take up practice-linked identities, how such identities were made available to them and how they practiced said identities in an SSI setting. Additional attention was given throughout this study upon the students' willingness to actively participate in resolving a current socioscientific issue that deals with global malnutrition. I collected data using individual interviews about participants' experiences in practice, as well as additional field observations and a collection of media clippings and have interpreted those data in light of a practice-linked identity perspective.

## Review of Literature

This study draws upon two theoretical perspectives to understand the ways in which participating in a socioscientific project mediated students identities and how this school-based setting supported their identity development. The first theoretical perspective arises from the SSI literature. The second theoretical perspective is that of identity as an analytic lens in educational research (Gee, 2000; Sfard & Prusak, 2005), especially in the sense of constructing a personal identity positioned within the context of a specific practice (Nasir & Hand, 2008).

### The SSI approach

***Terminology.*** SSI make up for science-based social dilemmas consisting with moral and ethical elements, that are used to advance the broad term of scientific literacy, one that embeds the knowledge and understanding of science within the context of effective social agency (Sadler, 2004). The basic assumption of the SSI approach is that dealing with such complex issues allows students to actively use scientific knowledge in solving societal problems and, through acting on these problems, to increase students' interest in science and to provide them with learning experiences that go beyond the walls of classrooms (Sadler, Barab, & Scott, 2007; Zeidler et al., 2005). Negotiating such issues involves understanding the content of an issue,

requires the use of evidence-based reasoning, and provides a context for understanding scientific information through a moral and ethical lens (Lee et al., 2013; Zeidler et al., 2005).

***Character education.*** At the time this thesis was written, the global media was extensively covering SSIs that extend well beyond personal and local concerns, ranging from Zika virus epidemic concerns (Fauci & Morens, 2016) to Syrian refugees nutritional crisis and subsequent starvation (Bilukha et al., 2014). These current concerns bring about calls for educating students as global citizens who are capable and willing to resolve these issues while working toward providing a safer, more just global community. In order to accomplish this goal, science educators and researchers call for the integration of science education with moral and character education (Bencze & Carter, 2011; Berkowitz & Simmons, 2003; Hodson, 2003; Lee, Chang, Choi, Kim, & Zeidler, 2012; Lee et al., 2013). Recognizing the complex notion of character education, Berkowitz and Simmons (2003) defined character education as one that "encompasses all aspects of schooling that impact upon the development of social and moral competencies including students' moral values, moral personality, moral emotion, moral reasoning and moral identity". Zeidler et al. (2005) goes on to position character development of learners as an important aim for science education and argue that the development of students' character could potentially be promoted through engagement with SSI (Zeidler, 2005).

Expanding on that notion, several researchers have attempted to understand the relation of science education, while emphasizing SSIs, to character education and development. For example, Tal and Kedmi (2006) assessed students' value judgment as expressed in their resolution patterns of SSIs. They showed that students from 10th and 11th grades who participated in an SSI unit exhibited both an increased awareness to the conflict in question and a value-based resolution which indicates an improved value judgment. Lee et al. (2012) designed an SSI unit that deals with nuclear power plants in an attempt to examine pre-service teachers' moral values related to SSIs. Although the research documents an increased sensitivity to moral and ethical components of scientific and technological development, at the end of the unit's implementation participants tended to prioritize the economic profits of their own country and afforded restricted consideration to the ways their decisions could affect other people in different places of the world.

***Science for socio-political action.*** Preparing students to actively participate as citizens who contribute to their societies is considered a primary goal for both character education and for science education (Berkowitz & Simmons, 2003), and SSIs are considered as means to promote this goal (Zeidler et al., 2005). This notion is echoed in new visions of scientific literacy which argue for the expansion of the definition of scientific literacy to include students informed socio-political action on issues that involve science and technology (Dos Santos, 2009; Hodson, 2003). Hodson (2003), advocating a science curriculum that emphasizes socio-political action, proposes a convenient scheme for the development of scientific literacy that can be addressed at four levels of sophistication, namely students are required to: (1) appreciate the impact of scientific developments, and recognize that science and scientific developments are, to some degree, culturally determined, (2) Recognize that decisions about scientific developments represent different stakeholders, and are linked with the distribution of wealth and power, (3) Formulate individual views and establish corresponding value positions, and (4) Prepare for and take action. In a similar manner, Dos Santos (2009) re-conceptualized Paulo Freire's (2000) liberating pedagogy to make it applicable to science education. He suggested a humanistic perspective to scientific literacy, which consists of three stages: (1) encouraging students to identify current social issues for discussion by observing reality, (2) initiating a dialogical process through which students could debate and discuss said issues, and (3) translating students' understanding into sociopolitical actions. Following these progressive new visions of scientific literacy, many science educators and researchers advocate the vision of students as active citizens who are willing to participate in both discourse and actions aimed at resolving SSIs in ways that serve the overall wellness and common good of global communities (Bencze & Carter, 2011; Hodson, 2003; W.-M. Roth & Désautels, 2002; W. M. Roth & Lee, 2004).

Advancing the notion of students' socio-political action on SSIs is a much-needed, but a daunting, task. When school science systems pay attention to SSIs, it appears to be limited to asking students to negotiate current issues and to produce arguments to defend their positions on the issues. Asking students to take actual action in attempts to resolve the issue appears to be less common (Bencze, Sperling, & Carter, 2012). Struggles to promote students' socio-political action go beyond school systems limited attempts to engage with SSIs. For example, Lee et al. (2013) implemented an SSI

learning unit on genetic modification technology with the aim of promoting elements of students' character and values as global citizens. Although students became more sensitive to moral and ethical components of science, they still struggled to demonstrate willingness and efficacy to participate within broader communities that entailed action toward SSIs resolution. Sternang & Lundholm (2011) also present similar findings. They analyzed interviews with lower-secondary school students to understand students' conceptions of how to address the effects of climate change. They showed that students are not usually willing to take action, even though they see an action as the moral thing to do.

***Socioscientific Inquiry Based Learning.*** Taking socio-political actions on scientific issues requires students to make the transitions from discussing SSIs in theory to proposing concrete solutions. For these solutions to be considered legitimate, they ought to rely on students' understanding of scientific practices, concepts, and theories (Hodson, 2003). In that sense, integrating SSI with inquiry-based learning is advocated as a means for developing such understanding (Levinson & The-PARRISE-Consortium, 2014). The EU-funded PARRISE project integrates learning based on SSI with inquiry-based science education (IBSE) approach and, thus creating a new pedagogical framework entitled Socio-Scientific Inquiry Based Learning (SSIBL). This pedagogy aims at empowering students to be able to engage in debates about the social aspects of science and technology and promotes civic actions through inquiry activities in schools (Levinson & The-PARRISE-Consortium, 2014)**.**

## Identity as an analytical lens for research in education

***Terminology.*** Identity is a multidimensional and complex construct receiving progressively more attention in educational research, including in the domain of science education (Sfard & Prusak, 2005). Although it gets a wide recognition, the literature does not represent a consistent idea or definition for the term *identity*. While, several theorists perceive identity as a global stable construct that a person carries with him/her across settings and contexts (Arnett Jensen, 2003; Brewster, Suutari, & Kohonen, 2005), other theoretical perspectives perceive identity as a local construct that shifts in relation to the setting, practice, and context in which it is built (Gee, 2000; Nasir & Cooks, 2009; Nasir & Hand, 2008; Sadler, 2009).

In this thesis, I use identity in its locally constructed definition. In this context, Gee (2000) offers a useful description of identity by describing it as the "kind of person one is recognized as being, at a given time and place". He elaborates on this understanding as he describes identity as a dynamic entity that develops through an ongoing process and is affected by a person's relations with the world and with other people. That is, as individuals participate in new experiences, their identities may be modified or changed. Gee's (2000) conception of identity highlights how identity is context dependent and how it shifts in relation to different social settings. In educational settings, the multiple identities that students carry with them and further develop in the classrooms (as well as in informal settings) allow them to act in particular ways according to the setting in which they are participating (Sadler, 2009). The concept of renegotiating identities across different educational settings is shared by other education researchers (Nasir & Cooks, 2009; Varelas, 2012).

Since the definition of identity deals with the notion of "who one is", it allows researchers to ask broad questions about the nature of participation and learning in educational settings. For example, Barton (1998) describes how urban homeless students are marginalized by traditional school-science practices because they give rise to narrow science identities that do not appeal to them. Sfard and Prusak (2005) compared the learning processes of two groups of $11^{th}$-grade math students; recent immigrants from the former Soviet Union and native Israelis. They argue that differences between learning processes might be related to identity issues relating to the immigrant status of some of the participants, which amplified their need for success. In that sense, they argue, learning mathematics served as a mean for closing the gap between who the students are now and who they want to become. Rahm (2007) examined students' interactions with scientists in a youth summer science program, utilizing theories of identity. She highlights the ways in which these interactions allowed students to gain recognition and confidence in science and thus assisted students in defining new positions for themselves in science.

***Practice-linked identities.*** Situated cognition theories articulate the connection between learning and identity development. Lave and Wenger's (1991) theory of communities of practice, for example, highlights the benefits of learning by participating in daily activities of a domain one is a member of. Communities of practice present a theory of learning in which learning is perceived as a process of increasing social participation (Lave & Wenger, 1991; Wenger, 1999). Rather than

focusing on individual learning of bodies of facts and theories, Lave and Wenger's (1991) theory focuses on learning as a function of being a part of a community in which a group of people with a shared vision, beliefs and understandings engage on a continuous basis in some joint enterprise. This shift, from the individual's context to the community context, has extensive implications for what it means to understand learning. According to the communities of practice theory, individual learning is an issue of engaging and contributing to the practice of the community, whereas for the community as a whole, learning is an issue of refining the community practices (Wenger, 1999).

Wenger's (2000) later theoretical approach further deepens the connection between learning and identity. At the base of his theory is the idea that identity is constructed at the intersection between the personal and the social world. He argues that, as students begin their participation in a community of practice, such as the science classroom, they learn and develop identities through engaging with the practices and tasks of that community. From this perspective, both learning and identity depend on shifts in participation in social and cultural practices. However, members of a community of practice take different and individual forms of participation. In addition, not all practices are equal with regards to their ability to support identity development (Nasir & Hand, 2008). Highlighting the notions of individual participation and supportive environments for identity development, Nasir and Hand (2008) introduced the term *practice-linked identities* to describe the connection between the individual and the practice. They describe practice-linked identities as "identities that people come to take on, construct and embrace that are linked to participation in particular social and cultural practices" (Nasir & Hand, 2008). The connection between the individual and the practice can be measured by three identity resources that, the authors argue, are important for engagement with the practice (Nasir & Hand, 2008):

(1) *Access to the domain* – which the authors define as "the extent to which participants have the opportunity to learn both about the practice as a whole and about the specific tasks and sub-skills that make up the domain";

(2) *Integral roles* – which the authors define as "the extent to which participants are held accountable for particular tasks in a practice and are expected to become competent and even expert in a subset of activities that are essential to the practice";

(3) *Opportunities to make a unique contribution and feel valued* - which the authors define as "ways that students can incorporate aspects of themselves into the practice".

Nasir and Hand (2008) conducted a study that compared the extent to which these three resources are available to high school students who were learning to use math in a classroom setting, in contrast to those available to them on the basketball court. They argue that classroom mathematics is less engaging in comparison to the basketball team, and thus yields less meaningful learning because classroom mathematics afforded youth narrow identity resources in the form of limited access to the domain, minor opportunities to take up integral roles, and fewer opportunities for self-expression.

Building on these two conceptual frameworks, the focus of this study is on the ways in which students practiced and built their identities through participation in a socioscientific setting. Further, I examine how this setting allowed for a deep engagement by the students that resulted in their willingness to actively participate in resolving SSI.

I have found it useful to use the identity analytical lens to explore the students participation mainly because dealing with SSIs allows for multiple connections the students' world views by associating science with moral aims (Zeidler et al., 2005), and by linking social values to action on science-related issues (Bencze et al., 2012). For these reasons, dealing with SSIs allow students to web scientific concepts with their personal identities.

As well, Sfard and Prusak (Sfard & Prusak, 2005) argue that the notion of character as an analytical construct is ill-fitted to sociocultural research because it evokes connotations of natural and biological, and therefore fixed, traits. The notion of identity, on the other hand, is perceived as an ever developing construct which is created and re-created in interactions between people and settings. For this reason, they argue, identity is a much more fitted construct for sociocultural research (Sfard & Prusak, 2005).

Joining Wenger (1999) in associating identity formation with practice, the basis for my analysis is grounded in Nasir and Hand's (2008) theory of practice-linked identities. I specifically use their three types of identity resources (namely access to the domain, integral roles, and opportunities for self-expression) to look into students' participation in a school-based socioscientific project, exploring the following research questions:

- What resources were available for students' identity development in a school-based socioscientific project and how were these resources used?
- How having access to these resources mediated students' identities?
- How can practice-linked identities theory inform activism in science education?

## Methodology

### Research approach

In light of the research questions, I chose to utilize the naturalistic paradigm and a qualitative research design. The naturalistic paradigm is based on the assumption that realities are constructed by people, and there is no one objective truth (Lincoln & Guba, 1985). The research is performed under a case study approach. Utilization of a case study approach allows the researcher to generate an extensive and descriptive analysis of a particular and multifaceted case that is of interest (Patton, 2005). Case studies employ various methods, for example, interviews, participant observations and field notes with the intent to catch the complexities of a single case. The goal of these methods is to reconstruct and analyze a case from a sociological perspective (Patton, 2005). I chose a case-study approach because the research questions of this study demanded an in-depth understanding of the situation and its meaning for the participants of the study (Denzin, 1973).

### Framework for research methods

Following Seidman's (2013) method of interviewing (see *data collection and resources* section), this study is grounded in the research traditions of both narrative inquiry and phenomenological inquiry.

***Narrative inquiry.*** Narrative inquiry consists of gathering data in the form of people's stories and reporting their experiences. In telling their stories, individuals can reveal cultural, political, social and psychological dimensions of human experience (Chase, 2005; Patton, 2005). Sfard and Prusak equate narratives, or the stories one tells about himself / herself, with the construct of identity. They argue that narratives afford a mechanism for capturing the ever continuing process of identifying, as narratives are "discursive counterparts of one's lived experiences" (Sfard & Prusak, 2005). That is,

identities are expressions of activity and experience embodied in the stories one tells about him / herself. These stories change over time and across contexts. For this reason, it seemed fitting to utilize the narrative inquiry approach in this research. There is a certain degree of flexibility in narrative inquiry. The researcher is not confined to tell an extended narrative that spans participants' entire life experiences. Instead, short stories on a tightly defined topic can be collected. That is, the final product of narrative inquiry approach can either be organized in the form of extended life stories or short vignettes (Chase, 2005).

***Phenomenology.*** Phenomenology is both a school of philosophical thought and an interpretive theory that is often used in studies that consider the meaning of experience (Patton, 2005). Phenomenological studies focus on exploring and understanding the different ways in which individuals experience certain phenomena. Interviews with people who have directly experienced the phenomenon of interest is typically the primary data source (Patton, 2005). By comparing data from more than one individual, researchers can explore different ways of understanding and thinking about the phenomenon. The phenomenon of interest to this study was students' experiences and engagement in an SSI oriented project. I intend to explore this phenomenon in order to better understand what this particular experience is like for the participating students. Phenomenology was selected as an appropriate methodology for this study because it allows for the incorporation of multiple interpretations of a given phenomenon, which is important as students experienced their participation in the project in different ways.

## Research context

The Spirulina project is a voluntary program for high school students in Herzeliya Gymnasium in Tel Aviv aiming at optimizing the growth conditions of the cyanobacteria *Arthrospira* (Spirulina) as a protein-rich dietary supplement. The project began in summer 2013 and currently enrolls some 40 students in this high school.

The project started when the students identified the current and burning humanitarian crisis in sub-Saharan Africa, mainly the need to find a solution for the nutritional threat African citizens face and decided to take action to solve or reduce it. The goal

of the Spirulina project in this school was thus to develop a growing method with the aim of spreading the Spirulina in under-developed countries in order to enrich their citizen's diet with proteins. For this aim, the students developed a cultivation method for the Spirulina that not only can support optimal growing conditions, but that is also simple and cheap in a way that may allow everybody who wants to, to grow the Spirulina on their own. In that sense, the students grow the Spirulina in re-purposed plastic bottles (Fig. 1) as well as in open pool-like containers. Senior students ($11^{th}$ or $12^{th}$ grades) who participate in the project are accountable for instructing newcomers ($9^{th}$ or $10^{th}$ grades) about the cultivation method. Some students also got to travel to different schools in Israel, as well as to remote places abroad, such as to South-Africa and Rwanda, in order to instruct others about their method. Thus, the students not only developed the growing method of the Spirulina, but they were also accountable for communicating their findings to others, locally, nationally and globally.

Figure 1. Using re-purposed plastic bottles in the Spirulina cultivation facility.

## Participants

Qualitative research usually examines a phenomenon using a small, purposefully chosen sample. Finding participants that have extensive knowledge about the phenomenon of interest is at the basis of the purposeful sampling technique (Patton, 2005). For this reason, the four students in this research were chosen because they were most recognized with the Spirulina project and were considered as its leaders. As well, all of them participated in the field trip to Rwanda, which is recognized as a key event in the story of the Spirulina project. Participants consisted of 11th and 12th-grade high school students who took part in the Spirulina project. The group was

composed of two females and two males. Of them, the two male students majored in science and the two female students majored in other subjects (Table 1).

Table 1. List of participants

| *Name | Major subjects | Gender | Grade | Seniority in the project |
|---|---|---|---|---|
| Dan | Computer science, Physics | M | 12th | 3 years |
| Karin | Arabic language, History | F | 12th | 3 years |
| Yonatan | Computer science, Physics | M | 11th | 2 years |
| Sanaa | History, Citizenship | F | 11th | 2 years |

*A pseudonym

## Case selection

Out of the four participants, two students were chosen as the case study students of this research, Yonatan and Karin. Yonatan and Karin's narratives helped highlight the major findings and the process of identity construction over the course of their participation in the project. Their selection was informed by observing their participation during activities that took place in the Spirulina project and their first interviews. The primary guideline for selecting Yonatan and Karin was how their narratives informed the research questions. For this reason, I sought students whose narratives for joining the Spirulina project and their experiences as participants aligned most with a practice-linked identity perspective (Nasir & Hand, 2008). I also sought students with whom I could comfortably establish a rapport (Seidman, 2013; Spradley, 2016). Finally, case study selection also aimed at maximizing the variation between the cases; including students' school science involvement, students' gender, and students' interests.

## Data collection and sources

Utilization of a qualitative research has some obvious limitations. Qualitative research does not attempt to capture reality. Instead, what is captured is individuals' construction of the ways they perceive reality (Lincoln & Guba, 1985). Recognizing

this limitation, I attempted to increase the study's internal validity through the use of the triangulation of several data sources (Patton, 2005). The main forms of data collection in this study were interviewing and observations.

***Phenomenological interviews.*** I conducted three in-depth interviews with all of the participants throughout the winter and spring of 2016, using a three-interview model as described by Seidman (2013). Seidman's (2013) model of phenomenological interviews emphasizes the importance of understanding individuals' actions within a particular context and how the meanings they make of a situation shape their actions. This model combines two forms of interviewing. The first form is based in life-stories interviewing, which allows participants to describe their stories through a dialog with the researcher (Patton, 2005; Seidman, 2013). The second form is based on in-depth phenomenological interviewing, which enables an understanding of individual participants' conceptions of a particular phenomenon (Schutz & Luckmann, 1973). The goal of such interviewing method is to allow the participant to reconstruct his or her experience in the context of the topic under study. Patton (2005) argues that phenomenological reflection has to be recollective and retrospective by its nature, that is because a person cannot reflect on lived experience while living through the experience. In other words, phenomenological reflection is a reflection on an experience that has already passed or lived through (Patton, 2005). Accordingly, this study examined students' experiences in an SSI oriented project as revealed through retrospective interviews, in which participants were asked to recall past experiences.

For this purpose, Seidman (2013) suggests conducting a series of three in-depth interviews. The first interview is focused on the broader context of one's participation. In this interview, I have asked the participants to recall major events from the moment they have joined the project to the moment of the interview. The second is focused on concrete day-to-day details within a particular context. In this interview, I have asked participants to focus on a specific day from their trip to Rwanda and to describe in details their memories from the moment they woke up to the end of the day. The third interview is focused on reflections in the context of the previous two interviews. In the third interview, participants were asked to generate a map that can show the critical events and experiences which summarize their participation in the project. The instruction was to create a map in such a way that if a stranger looks at it, he / she could understand the students' experiences in the project

as a whole. Each interview was audio-recorded and lasted between thirty to forty minutes. The interviews were conducted in the school setting and then transcribed verbatim.

***Observations.*** Observations allowed me to explore the identities of the students further than interview data. Through observations, I was allowed to examine the students' identities in actual practice. This allowed me to compare observational artifacts with interview data that focused primarily on the students' identification with different practices.

I observed the students' in practice on three separate occasions. The first occasion was during a three-day course they gave to Rwandan farmers. The second occasion was during a teachers' professional development program, in which the students gave an extensive lecture about the Spirulina project, its aims, and the cultivation method. Both of these events took place in the school setting. The third observation was during a one-day inquiry activity that took place in the teaching laboratory of the Department of Science Teaching at the Weizmann Institute of Science.

Observational tools included audio records, video records, field notes, and photographs. During observations, I acted as both a non-participant observer and a participant observer (Yehoshua, 2003) depending primarily on invitations from the students and the school faculty.

***Documents review.*** In addition to interviews and observations, documents were also collected and reviewed to understand students' experiences. Collected documents included various newspaper clippings and school-level promotional material.

## Analysis

Data were analyzed and interpreted using a hybrid process of inductive (bottom up) and deductive (top bottom) analysis. This approach could complement the research questions by allowing the philosophical framework of theories, such as Nasir and Hand's (2008) practice-linked identities, to be integral to the process of deductive analysis of students' participation, and to also allow for themes to emerge directly from the data using an inductive coding scheme. For this purpose, a combination of theoretical constructs (Nasir & Hand, 2008) and of the grounded theory (Strauss &

Corbin, 1998) were used to create codes and coding categories. I included two phases of data analysis: focused coding based on literature and open coding.

***Focused coding.*** The first phase included reading the entire corpus of data and involved a deductive analysis method. During this phase of analysis, I applied codes to the data based on theory and my research questions. The first phase of analysis helped to establish the superordinate themes. The codes for this phase were grounded in Nasir and Hand's (2008) theory of practice linked identities and included the broad themes: Access to the domain, Integral roles, and Opportunities for self-expression in practice. Nasir and Hand's (2008) theoretical framework directed my analysis to particular aspects of students' experiences related to practice-linked identities.

***Open coding.*** The second phase involved inductive analysis method. During this phase, rather than applying any particular theory to the data, I open coded the data using the grounded theory (Glaser & Strauss, 2009; Strauss & Corbin, 1998). Grounded theory is described as an array of procedures for the development of an inductively developed theory, allowing themes and categories to emerge from the process of iterative readings of the data and through the utilization of a constant comparative method that allows the researcher to interpret meaning from the collected data (Strauss & Corbin, 1998).

Hutchinson (1986) argues that grounded theory can serve the four basic functions qualitative data contributes to theory: to initiate new theory, or, to reformulate, refocus, and clarify existing theory. For this reason, grounded theory may be especially useful for the elaboration or for the interpretation of Nasir and Hand's (2008) practice-linked identities theory. Therefore, in this study, the grounded theory helped to generate more fine-grained categories and related subthemes**.** Following the identification of the subthemes, I mapped all the transcripts according to the chosen categories. During this phase, I also identified particular segments of interviews in which students declared specific willingness for taking action on SSI. Some of the added codes occasionally overlapped codes developed during the open coding process in specific utterances. This overlapping later informed some findings regarding students' willingness for taking action.

Interviews were typically coded by utterance, except for instances where the utterance was too long and complex. In such case, utterances were segmented when there was a

change of topic. In addition to coding data on the two case studies selected for this study, I also coded data from the other two cases.

Categorization was carried out independently by two researchers. The level of agreement between the two independent categorizations was 85% and reached 100% agreement after deliberation.

## Results

Following Nasir and Hand (2008), I chose to craft Yonatan's and Karin's narrative in a form of three interwoven vignettes, each represents a superordinate theme: *Access to the domain, Integral roles*, and *Opportunities for self-expression*

### The case of Yonatan: closing the gap between actual and designated identity

Yonatan, an honorary student in the 11$^{th}$ grade who majors in Physics and Computer Science, joined the 'Spirulina' project in the summer vacation between the 9$^{th}$ and 10$^{th}$ grade, which was about one year after the project started. He is very sociable, confident, and popular among his fellow schoolmates. Yonatan is not the loudest or most outgoing participant in the Spirulina project, but still, he holds high status in the Spirulina project and presents himself as the "next generation" of students who runs the project, a title that other students who participate in the project also attributed to him.

In the next section, I describe the themes that allowed me to craft Yonatan's narrative and the ways these themes appeared to support his participation in the Spirulina project and permitted his identity development. The analysis revealed several subthemes which permitted Yonatan's deep engagement in the Spirulina project (Fig. 2).

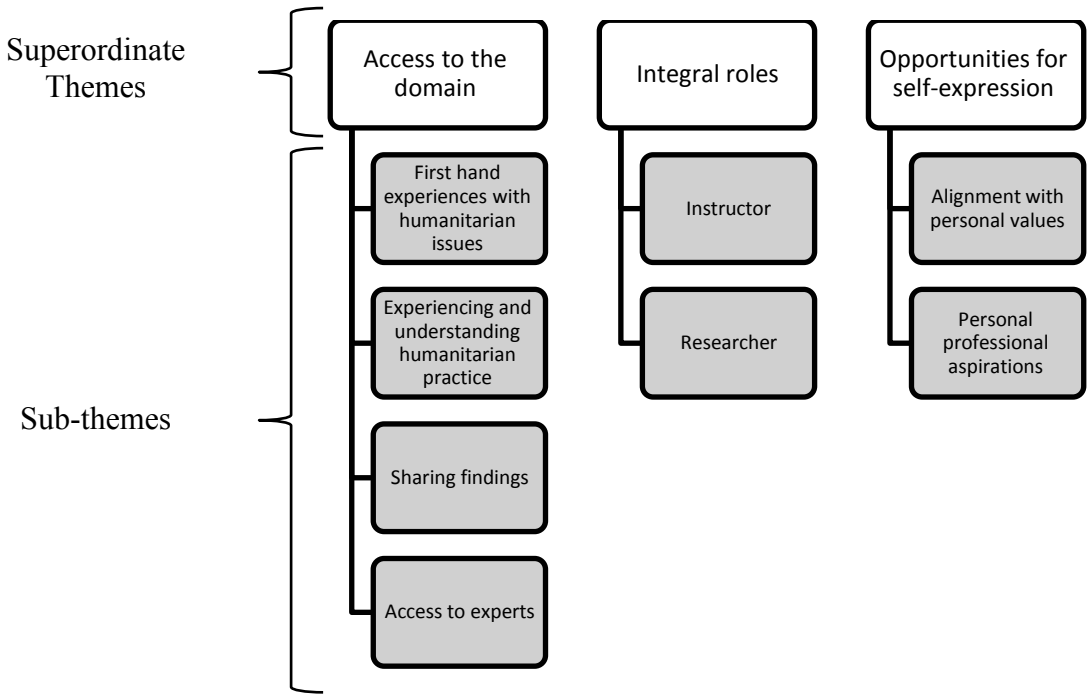


Figure 2. Superordinate themes and subthemes in Yonatan's' narrative (following (Nasir & Hand, 2008)

**Access to the domain**

***First-hand experiences with humanitarian issues.*** While not an academic domain, the domain of the Spirulina project includes as many rules, practices, and resources as domains such as math, science, and social studies. In the environment of the Spirulina project, Yonatan used multiple resources to examine the project's domain. The most reoccurring subtheme in his access to the domain vignette was one of the field trips to Rwanda, where he and other leading students (accompanied by the school principal and an additional adult) worked with government officials, schools, and community health centers to promote of Spirulina cultivation in Rwanda. The importance of this trip to Yonatan was momentous. When asked during his third interview to generate a map of the critical events and experiences he had during his participation in the project, Yonatan chose to plot a graph of dependent and independent variables (Fig 3). The dependent variable was the meaning of the project to him, and the independent variable was time, which was marked by significant events. Most evident in his graph is the steep incline in meaning which marks the trip to Rwanda. In his accompanying narrative, Yonatan explains why the trip was so important to him by describing the overwhelming humanitarian conditions and adversity which he witnessed in the Sub-Saharan country. For him, this field trip was not only valuable

for the experience in itself, but also a way of seeing the legitimacy of the project's aims.

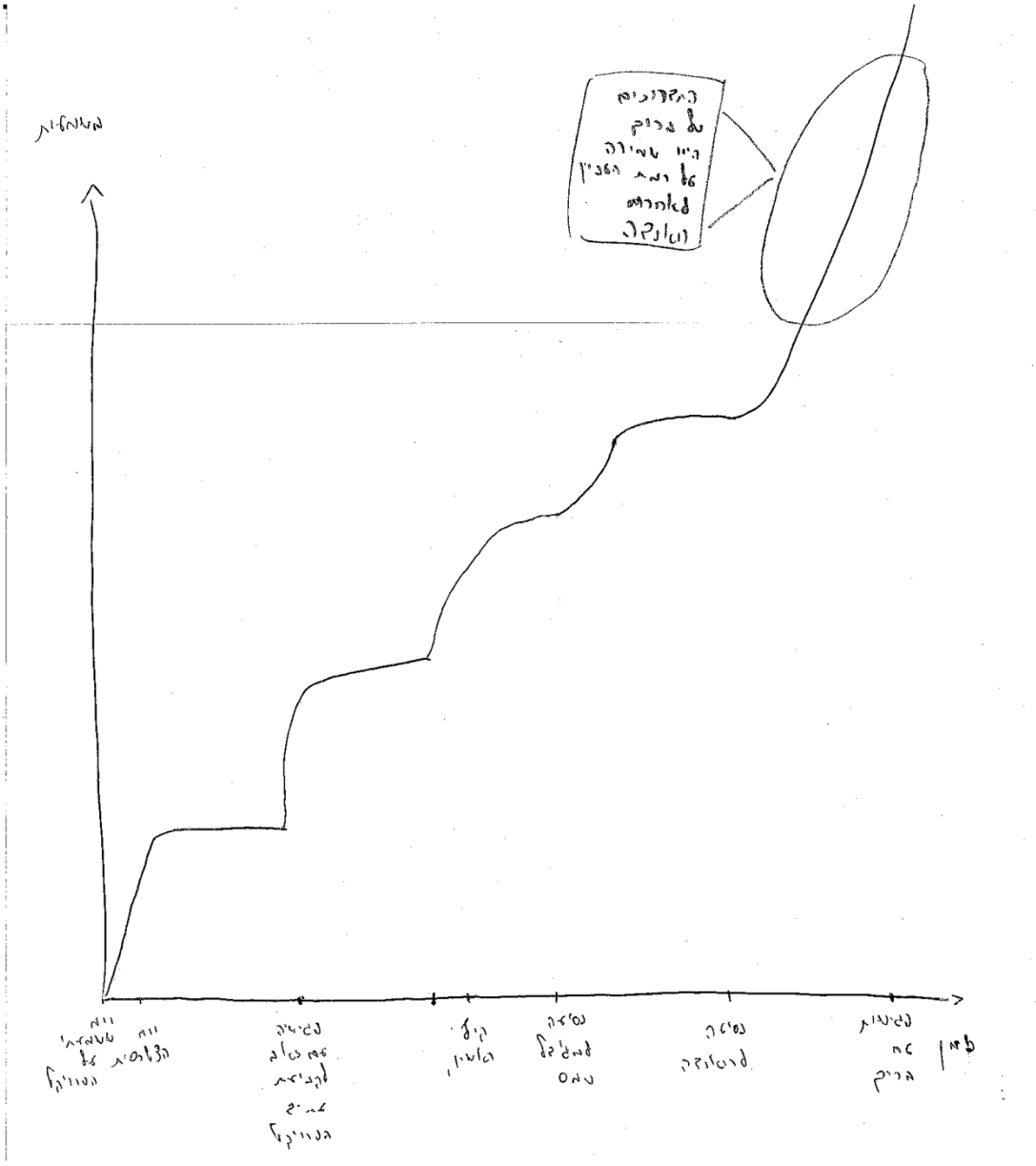

Fig 3. Yonatan's map of critical events

*Yonatan: You know, in Rwanda it really hit me. We were very close to the people living there, and that means seeing people in the streets, seeing how they live, seeing the slums…experiencing water shortage because rain season hasn't started yet and you can't shower. All of it made me realize that this could happen to anyone. (Yonatan, first interview, 7 Jan, 2016)*

In this quote, we glimpse into some of the factors in the field trip which allowed Yonatan increased access to the domain. Undoubtedly, witnessing the conditions in Rwanda first-hand was informative for Yonatan and he was able to experience some of the harsh conditions in Rwanda, such as water shortage and poor living standards. Being aware of those conditions made him what is most interesting is the way he appropriates what he had witnessed:

*You know, most of the people [in Rwanda], their lives are very different from ours. Suddenly, I realized that their happiness is different from our own – I am happy when I get a new computer or a PlayStation game. They are happy when they get water. All of a sudden, I started to realize that these gaps should not exist, and if I can do something to change it, then why shouldn't I? It was most intense when I met young kids…it evoked something in me, that once, I too was a young child, and it could have been me [in their place]. (Yonatan, first interview, 7 Jan, 2016)*

Describing his motives to act on the issue of malnutrition in under-developed countries, Yonatan focused on the human element of the issue and placed the welfare and comfort of the suffering parties in the forefront, while also contrasting it with his own comfort. Doing so, Yonatan reveals what Sadler and Zeidler (2005) described as emotive reasoning, defined as "consistent with the application of moral emotions such as empathy and sympathy". They claim that individuals, who have revealed emotive reasoning patterns, seem to truly care about the wellbeing of others. It appears that the trip to Rwanda was informative to Yonatan in a socio-affective manner, to the extent that allowed him to identify empathetically with others who suffer from malnutrition. Subsequently, Yonatan's emotions of care and empathy had significantly contributed to his consideration of the issue of malnutrition in underdeveloped countries and to his willingness to take sociopolitical action in order to resolve it (Fig. 4). In other words, by experiencing the emotionally intense visit to Rwanda, Yonatan was provided with an increased access to the domain of the Spirulina project as a whole, which then allowed him to develop emotions of care and empathy which directed his willingness to participate in the project.


Figure 4. Schematic representation of the process of increasing access to the domain through first-hand experiences of humanitarian issues leads to feelings of accountability and willingness to act

***Experiencing and understanding humanitarian practice and sharing findings.*** Participating in the Spirulina project also fostered access to the domain by confronting students with the actual challenges and difficulties that humanitarian aid workers could face, which allowed them to understand what it is like to be a humanitarian practitioners. This made Yonatan understand that solving a humanitarian issue can be deterring. Most frequently, Yonatan spoke about his and his peers' difficulties in persuading other students to establish their own Spirulina growing facilities in their schools, which could later be used by their communities. Referencing the difficulties he experienced as a participant in the project, Yonatan specifically focused his frustration on the practice of instructing others about the growing method of the Spirulina. The challenges Yonatan identified ranged from language barriers to finding a way to excite the crowd. For example, the following answers were given in response to questions about whether Yonatan believes the instructions were beneficial to the audience:

*Mostly, they just stared at us with blank faces, [asking themselves] what are they doing here? What's going on? And when we asked them "do you understand?" they nodded with confirmation, and they took notes, but I had the feeling that they just wanted to go home. (Yonatan, second interview, 5 April, 2016)*

Or,

*I think that they had an understanding, but that they didn't want to initiate things on their own. They wanted us to be the leaders; they wanted to take instructions from us. (Yonatan, second interview, 5 April, 2016)*

Articulating his frustration, Yonatan describes a lackluster behavior on the part of those he is trying to give aid to, whom, as he perceives it, either reject the students attempt for help, or passively wish to remain dependent for their survival on the student's assistance. This prompted Yonatan and his peers to discuss, reflect and give each other feedbacks on their actions as instructors, which made the task of instruction a bit more transparent and explicit:

*We came back to the hostel [in Rwanda], and we had a discussion between us about what worked in the instructions and what didn't work. We realized that transferring it [the idea] to other people is really hard. (Yonatan, second interview, 5 April, 2016)*

And also,

*After Rwanda, on the plane, we asked ourselves: "what have we achieved?"…it looks like such a simple equation – you bring the algae, they grow it, problem solved. But, there are so many different factors…the hardest part is to transfer [the idea], to make other people take the lead. (Yonatan, first interview, 7 Jan, 2016)*

By experiencing the complex environment in which humanitarian practitioners work, Yonatan was able to identify the weaknesses of his instructions and of the Spirulina project as a whole. These experiences led him to realize that the students' vision of the project and their attempt to resolve the issue of malnutrition in under-developed countries may not be plausible in reality and that some changes in the vision of the project are required, a feeling that was shared among the other students who went to Rwanda. Understanding that there is a limit to what they can achieve was very important for the progression of the project because it prompted discussions between the students in an attempt to improve their practice. Some of Yonatan's own ideas to improve his practice were to "add some humor, bring some graceful examples" into the instructions, to "mingle with the children" before the instructions, or to "focus on an audience that you know is already interested" *(Yonatan, second interview, 5 April, 2016)*. Because Yonatan and his peers were able to experience the practice of humanitarian aid workers and to share their findings of the practice, it made the task of participating in the project more accessible to them and, consequently, made them more competent in the practice of the Spirulina project.

***Access to experts.*** Another aspect which allowed Yonatan's increased access to the domain of the project was his work with experts. As part of their practice, Students in the project had regular and sustained contact with experts with which they have worked to translate their ideas to specific functional aspects within the project. There are, of course, many ways of enacting expertise, here we use the term expert to characterize professionals in their respective fields. In that manner, expert consultants to the project included Spirulina cultivators, scientists, and science education researchers. These partnerships gave participants access to resources which the students perceived to be important to the project, and which were otherwise not available to them. Yonatan's appreciation for this aspect can be seen in his map, where he highlighted the instructions that were given by one of the experts on Spirulina cultivation. The expert is a professional Spirulina farmer, whose expertise is in growing Spirulina in special dedicated pools for commercial purposes. The instructions were 2 hours long and took place in the school on every other Friday. About 40 students enlisted to these instructions, most of them were novice participants in the Spirulina project. Yonatan explained that these instructions were important to him, and to the project, mainly because they allowed him and other novice students to better understand how to grow the Spirulina. For these novice students, these instructions served as a kind of scaffolding which allowed for a better cooperation between the participating students and, gradually, made them more competent.

**Integral roles**

The activity structure in the Spirulina project required many competencies from the students: researching and developing the growing method, cultivating the already growing Spirulina, instructing others about the method, meeting with municipal and government officials as well as with NGO officials, fundraising, and reporting to the media. All participating students fill all of the positions but, naturally, some students feel more comfortable in one position than in the other. This closely resembles Nasir and Hand's (2008) notion of *integral roles*, which they define as "the extent to which participants are held accountable for particular tasks in a practice and are expected to become competent and even expert in a subset of activities that are essential to the practice."

***Yonatan as an instructor.*** When he first joined the project, Yonatan took a moderately involved positioning with respect to the project, stating that he didn't really believe that the project could ever achieve its aims, however, this position shifted after a while. The interest Yonatan discovered was not an abstract one, but wrapped up with the integral role he had as an instructor in the project and in the opportunities that the instructor role afforded him. This role was significant and carried with it an audience outside the school. Thus, it also made Yonatan a public representative of the program and central a member of the Spirulina project.

Yonatan's competency as an English speaker was supportive of his role as instructor. Not only that he is a confident and fluent speaker, he has excellent communication skills in English. While some of the students who participate in the Spirulina project struggled with speaking English when giving lectures to foreign African citizens, Yonatan stood out among his peers, delivering eloquent and relaxed instructions in English. This was a major advantage in a project that focuses mainly on student's lecturing and dissemination. This advantage served as a resource that helped Yonatan to take up the role of an instructor. Moreover, Yonatan saw an alignment between his role as an instructor and his own personal values and ethics. When he started to instruct others, he said, he began to realize that the project could actually succeed and that his personal values, ideals, and moral aspirations could take shape. This role mattered to him to the extent that it affected his participation in settings outside of the context of the project:

*It was really weird seeing people sitting in front of me and listening to me, but I got hooked! Just now, my teacher asked me to give a presentation about Israel's gas layout, and I spoke freely because it wasn't new to me. (Yonatan, second interview, 5 April, 2016)*

Though he probably did not have the same opportunities or support in his classroom as in the Spirulina project, in this quote Yonatan expresses his ability to easily transfer the passion he had found in the role of instructor in the Spirulina project to another domain, the traditional classroom. Having discovered his passion, Yonatan was now ready to expand his role as instructor and to start lecturing to other students outside of the Spirulina team. His first instruction to students outside of his school was to Druze students in Majdal Shams. This event is also marked on Yonatan's map (Fig. 3).

Happening with the expansion of his role as instructor are multiple expressions of frustration which stem from Yonatan's inability to convince the audience of the necessity of the Spirulina growing facilities to their communities. For example, in Majdal Shams, for the first time, he got the feeling that the audience was passive and not really paying attention to his instructions. That was when he first realized that instructing other students, who are not part of the conception of the Spirulina project, can be a daunting task, mainly because they do not share the same enthusiasm and willingness to act as the students from the project.

*They just don't get it… you have to see the importance of it, you have to give it more space. People need to come with a will [to learn]. If they don't come with a will, it won't work. (Yonatan, first interview, 7 Jan, 2016)*

Here, Yonatan Demonstrated his willingness and efficacy to take action aimed at resolving the issue of malnutrition. He explains his motives to act on the issue by acknowledging the importance of it, and he describes the effort he is prepared to invest by expressing his willingness to dedicate his time to these actions. It seems that he was not simply filling a role that was forced upon him, but that for him the role of instructor in the project truly did matter. While the notions of urgency and acuteness may have been obvious to Yonatan, he recognized that his attempts to transfer it to the students in Majdal Shams were unsuccessful and he said they had "difficulties connecting with them" and that it "missed the point".

A few months later, Yonatan received a unique opportunity to expand further his role as an instructor when he was asked to join the school delegation to Rwanda. The purpose of this delegation was, first and foremost, to instruct Rwandan school students about the growing method of the Spirulina with the intention of establishing Spirulina growing facilities in these schools, which ultimately will be managed by the Rwandan students. In the course of a week, the students visited and instructed students from three different schools, as well as some Rwandan farmers. There, once again he experienced difficulties with transferring motivation to act to other students. As mentioned in the *Access to the domain* vignette, Yonatan was frustrated from the instructions in Rwanda because he felt that the Rwandan students were indifferent to his efforts or unwilling to undertake the same actions he is willing to take.

*Basically, people don't like to invest their time in something new and it is very hard to create that feeling that you are learning something that is important, that is going to matter. Each and every one should come with that feeling. If you don't have it, it won't work. And we experienced it [in Rwanda], where some kids were more excited, some less…*

Describing his impressions from the instructions, Yonatan details the same feelings he had after the instructions to the students in Majdal Shams, that he is able to grasp the priority of the issue at hand, but that he is struggling to cultivate other students with the same understanding and with the ability to act on it. In the two opportunities that he had to expand his role as an instructor (in Majdal shams and in Rwanda) Yonatan experienced major challenges that restricted his role and led him to the realization that the students' effort to act on the issue is mostly limited to their own team and that their dissemination efforts were unsuccessful. When asked about his take-home lessons from the trip to Rwanda, Yonatan expressed his reservations from the instruction:

*This whole disappointment from the instructions, it made me think, what are we even doing here? It's like, we're here at school and we have this facility [where we grow the Spirulina], but out there, we can't transfer it to others…I had some doubts with regards to the project, but it passed because I figured that you just have to keep trying (Yonatan, second interview 5 April, 2016)*

Yonatan decision to "keep trying" was a result of his deep sense of accountability for his role as instructor. In many ways, the role of instructor carried higher risks than other roles, because the success or failure of the projects goal to resolve malnutrition in under-developed countries depended mostly on the dissemination efforts of the students. When asked what made him invest his time in preparing and improving his instructions he said:

*This idea, that you are on a mission, really clicked for me. That if it will work, it will solve a problem.*

The risks associated with his performance as instructor provided authenticity for Yonatan, which made it mattered in a significant way. His sense of commitment and

accountability to the role of instructor is also evident in his the lecture that he gave to Israeli teachers, where he expressed his intention to improve his skills as instructor:

*We came back from Rwanda with positive experiences and we hope to make more delegations and to teach what we know more properly*.

Yonatan expressed his intention to keep participating in actions aimed at resolving the issue of malnutrition. He exhibited a willingness to overcome the challenges he experienced in the role of instructor by improving his instructing skills. In summary, being an instructor in the project was perceived by Yonatan as containing high-stakes, which made the role more authentic. This led to an increased sense of accountability and willingness from Yonatan's side to keep acting on the issue (Fig. 5).

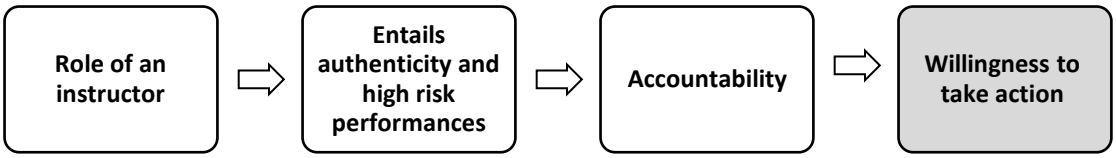


*Figure 5. Schematic representation of how taking on an authentic integral role as an instructor leads to Yonatan's willingness to take action on SSI*

***Yonatan as a researcher.*** The activity structure of the Spirulina project also afforded the participating students a chance to fill the role of researchers of scientific ideas and allowed them to use different scientific methods to explore these ideas. Interestingly, and though he is a science major, the integralness of this role was not very significant to Yonatan. When asked which role in the project he liked better - that of the researcher or the instructor, Yonatan clearly identified with his role as an instructor.

*Y: When you instruct a good group that comes with a good attitude, it is heartwarming. When you research, there's that thing of discovering new things, but when you instruct, it's completely different and you understand that you are a messenger.*
*I: What do you mean when you say you are a messenger?*
*Y: That if I wouldn't have done that, it wouldn't have happened. So, you feel responsible. (Yonatan, first interview, 7 Jan, 2016)*

When he describes himself as a messenger, Yonatan expresses his feeling of responsibility and accountability with regards to his role as instructor. It was not simply that he cared about instructing, but that he cared about instructing others with means of resolving an acute humanitarian issue. Yonatan was able to incorporate himself into the role of instructor, making it his own. He was not just filling the role, but he was uniquely needed in it. In this way, Yonatan's role was not just being an instructor in the project, but also an agent of humanitarian ideas. Note that he does not attribute the same urgency and essentiality with the role of researcher in the project, which he offhandedly reduced to "discovering new things". This notion, that the scientific investigation that supports the ideas and technology behind the Spirulina project is possibly inferior to the humanitarian work of disseminating the ideation behind the project came up again in his interview:

*The Spirulina, the science behind it is very simple. When you explain to someone that it is like growing tomatoes [it is as if you] don't consider it advanced science…the science is important and you need to understand what's happening there in order to grow it, but the humane part of it is much more important, in my opinion. (Yonatan, first interview, 7 Jan, 2016)*

Developing a straightforward and simple growing method was one of the main goals of the Spirulina project. It was meant to be simple in a way that everyone who would like to set up a Spirulina growing facility could do so with minimal requirements and funds. In order to communicate the simplicity of the growing method to others, Yonatan equates it with growing tomatoes. Though he reckons that understanding the details of the growing method is crucial, the simplicity of the method led him to believe that the scientific process and theory behind the development of the method is not very complex. Thus, it could be that he believed that competency in the role of the researcher was already achieved on his part, making room for him to focus mostly on the humanitarian practices of the project. This notion was also echoed by the high school principal who leads the project, when during the students' lecture to teachers he said:

*Principal: from the students who are in the project, almost none of them are majoring in biology. They major in humanity. That is why sometimes we have some gaps of*

*knowledge in specific areas, but we learn all the time and then we go to the lab to investigate. But we are looking at this from a different approach: we are not doing learning units in bio-research, the direction here is really the humane one.*

Though he brings back the attention to the scientific investigation process behind the students' growing method, the school principal, much like Yonatan, shifts the attention to the humanitarian practices. These quotes illustrate how particular roles for students were emphasized in the Spirulina project and how some were reduced. This reveals how the research practices were framed separately from the humanitarian practices. This juxtaposed framing made the role of researcher seems less appealing and important in Yonatan's opinion.

**Opportunities for self-expression**

***Alignment with personal values.*** Yonatan joined the project because it aligned well with his own personal philosophy. He said, "I saw a lot of responsibility in it, one that I already felt, a responsibility towards the world". Thus, for him, participating in the project allowed him to bring his own personal moral values into the daily practice of the project. This idea connects with Nasir and Hand's (2008) third tenet of an engaging learning environment: opportunities to make a unique contribution and feel valued, which they define as the way in which students can incorporate aspects of themselves into the practice. Co-occurring with Yonatan's personal values-laden motives to participate in the project, are references to his moral sensitivity and his need to show compassion for less-unfortunate others throughout the globe:

*I think that, if it is someone else's concern, it is my concern as well. And if there's someone who can't live because he doesn't have food, that I can't enjoy my food. And if someone who has to work all day and have to give up his studies, I feel my studies do not worth much. (Yonatan, first interview, 7 Jan, 2016)*

In this quote, Yonatan is highlighting the way his participation in the project is an expression of who he is. For him, the notions of empathic concerns and role-taking skills served as a driving force to act responsibly to resolve global issues, like third-world malnutrition. With relation to his practice in the Spirulina project, Yonatan was able to express himself through his belief system, inserting his personality and

emotions into the practice of the project, to make it more in line with his own identity. While Yonatan's ability to connect the context of the project to his own feelings and values lead to a more engaged participation on his side, it also situated his participation within a broader social context. Evidence for this notion can be seen in the quote above, where Yonatan recognizes the ethical and moral issues which threaten the human dignity of Rwandan citizens, such as malnutrition and child labor, and at the same time, he associates these issues with his willingness to participate in the project. Furthermore, during one of the student's lectures given to other teachers in Israel, when other students chose to talk about the nutritional values of the Spirulina, or about the individual, procedural steps of the growing protocol, Yonatan's lecture focused on how participating in the project affected him personally. Visibly excited, but still confident, he begins to connect the importance of the Spirulina project not only to his own life but also to larger humanitarian issues:

*Part of the idea that we are trying to convey here is that [we need] to teach more people, and then they need to teach [other people]. Also, I learned a lot about myself as well. I cannot think of the world as a place where only I live, I need to think about it as a whole. Sometimes, with globalization and the internet and what not, we forget that there are hungry people in Africa. We came back from Rwanda with positive experiences and we hope to make more delegations and to teach what we know properly. (Yonatan, Student's instruction to teachers, 8 Dec, 2015)*

Here, Yonatan displays moral awareness to those who suffer from malnutrition in third-world countries. In addition, he recognizes the problem that under-developed nations suffer as a result of the development of other nations. However, rather than simply acknowledging these issues Yonatan related them to his own personal experiences. He made the point that the student's actions in the project will play a role in addressing these issues and, thus, he was able to establish the importance of the Spirulina project for himself and for the audience and to give it legitimacy.
It appears then, that the Spirulina project provided Yonatan a powerful tool with which to explore current social issues because it allowed him to connect his own experiences and values to larger social issues.

***Personal professional aspirations.*** Another aspect of the Spirulina project that permitted Yonatan to express himself with relation to the project was the way it allowed him to identify a desired trajectory for his participation, and to develop his own professional aspirations by it. Sfard and Prusak (2005) argue that a person's identity narrative can be split into narratives that are either about the actual state of affairs, which they define as "actual identities", or narratives presenting a state of affairs which is expected to happen sometime in the future, which they define as "designated identity". The authors also state that a person will most likely experience a sense of unhappiness when there is a perceived and persistent gap between his actual and designated identities. This notion came up in Yonatan's narrative when his expectations of being able to help less unfortunate others were not met in reality, and he expressed his reservations with regards to his role as instructor in the project. For Yonatan, there was a considerable gap between what he expected to achieve from his participation in the project, and what he could actually achieve. His way to minimize this gap was to develop a new trajectory for his own professional aspiration to become a physician. Discussing his new trajectory as a physician, Yonatan said:

*In Rwanda, I saw a lot of people who required immediate help, and the Spirulina…the process of the Spirulina is very long, to teach others about it, and people are still dying in that time. But, if you are a physician and you have medical knowledge then you can give people immediate help and this is something that I would really like to do. (Yonatan, first interview, 7 Jan, 2016)*

If we unpack this transcript excerpt, we see that after visiting Rwanda, Yonatan came to realize that what he could achieve as a participant in the project might not be enough for the population of those who suffer from malnutrition and that a more immediate action is necessary. He concluded that he could serve this immediate action as a physician, and, as a consequence, is aspired to become one. In that sense, Yonatan's participation in the project served as a process of closing the gap between his actual and designated identities. Interestingly, when describing his intentions as a future physician, Yonatan focused on his desire to transfer the medical knowledge to other populations. Doing so, he made the connection between his role as an instructor in the project and his desired role as physician:

*After Rwanda, I realized that this is something I could do, to transfer my knowledge as a physician to [Rwanda]. (Yonatan, first interview, 7 Jan, 2016)*

This linking of Yonatan's prior experiences as a participant in the Spirulina project with his desired identity implies that his participation in the project provided him with sufficient support to cross the borders between the culture of the Spirulina project and his own life.

**Chapter summary**

Yonatan had a solid access to the domain in the Spirulina project. Having the opportunity to directly witness the situation in Rwanda and have unmediated contact with those he is trying to help, made the domain of the Spirulina project more transparent to him. Ultimately, the visit allowed Yonatan to employ sympathy, empathy, and genuine concern for the well-being of others and to guide his course of action, a pattern that closely resembles what Sadler and Zeidler (2004) termed as emotive reasoning. Yonatan also had a chance to examine the domain by figuring the practice of humanitarian workers and by sharing findings with other individuals regarding the success and failure of the project. Finally, having access to different experts improved the learning of knowledge and skills of all the participants, including Yonatan's, which rendered them more competent. Thus, the access to experts was integral to both individual and group progress.

Yonatan felt accountable for improving his skills in the domain of the Spirulina project through the roles he filled in the project, which, in Yonatan's case, mostly centered on the role of instructor. Yonatan was less willing to take up the role of the researcher for two main reasons: he had a sense of already achieved competence which rendered him less accountable to deepen his knowledge and skills as a researcher, and he positioned the role of the researcher in juxtaposition with the role of the humanitarian, prioritizing the later.

The Spirulina project provided Yonatan with new educational opportunities by supporting and encouraging self-expression. In particular, being able to relate ideationally to the project allowed Yonatan to express his own personal values and to bring them into the daily practice of the Spirulina project. Also, participating in the Spirulina project helped Yonatan to identify a desired career track in a science related

field, which further helped him to incorporate elements of himself into the practice of the Spirulina project.

**The case of Karin: Finding new ways to engage in and with science**

Karin is a 12th-grade student who majors in Arabic Studies and History. She speaks very fast, shows depth of thought, and is always straightforward. By all measures, Karin is considered a highly successful student in her school. She excelled academically, was very popular and was involved in some in-school activities. She is distinguished from her peers by her exceptional political awareness and involvement. Besides her participation in the Spirulina project, she was also a member of a model peace delegation, as well as an organizer of a national protest against the new edition of an Israeli Citizenship education course book. Karin joined the Spirulina project in the end of the 9th grade and was one of the first students to join the project. Like Yonatan, Karin entered the project with some concerns with regards to its application, but over time, she became the most vocal advocator of the Spirulina project. As such, she was interviewed to several national newspapers and online news websites in order to promote the project and to bring it to other people's attention.

Similar to Yonatan, the case of Karin is one of identity developing as a process of interaction with the resources afforded by the SSI themed project (Fig. 6). And indeed, their narratives share many similarities (as well as with the other students that participated in my study). However, unlike Yonatan, Karin is not a science major, and accordingly, her story is less about finding a desire for a career in science related fields, but Instead, Karin's story is about seeking new ways to learn and engage with science in a high school setting. For Karin, participating in the project motivated her science learning as well as created positive shifts in her science identity (i.e., seeing science as connected to the person she is, rather than disconnected). I argue that this identity emerged out of Karin's engagement with the Spirulina project, during which she was afforded an access to the domain of science, undertook scientific roles, and had several opportunities for self-expression.

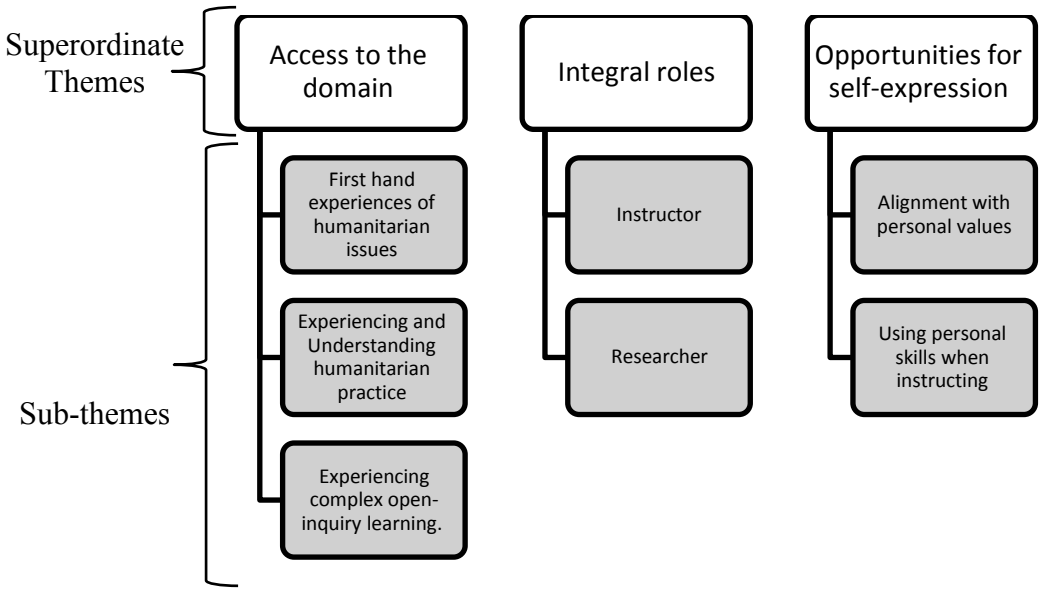


Figure 6. Superordinate themes and subthemes in Karin's' narrative (following Nasir & Hand, 2008)

**Access to the domain**

***First-hand experiences with humanitarian issues.*** Similar to Yonatan, directly witnessing the harsh humanitarian conditions in Rwanda was a significant experience for Karin. Being a more senior student in the project than Yonatan, Karin had the opportunity to also travel to Cape Town, South Africa with the aim of teaching South African students and citizens about the Spirulina cultivation method. In her narrative, however, she mostly focused on the field trip to Rwanda. In her map of the critical events and experiences, she regarded both field trips as significant and important to her and to the project but added that the trip to Rwanda was also a "traumatic experience which left a huge mark on me" (Fig. 7). In her interview, she said that she felt like the week of the trip was probably the most difficult week of her life and that she felt she was unprepared for the trip. She said that she was familiar with the situation in Rwanda even before the trip, but adds that directly witnessing it was a completely different experience:

*I've seen a lot of films and photos of kids with bloated bellies before, but to actually witness it in reality? it was very difficult. (Karin, first interview, 12 January, 2016)*

When I prompted her to talk about what made the trip difficult she said:

*Everywhere we saw poverty, famine and dying. [We saw] death, really. It was really really hard. (Karin, first interview, 12 January, 2016)*

She elaborated,

*It was like the poverty you only see in photos. Kids with no shoes, ripped bags, kids with bloated bellies, without teeth, little kids that should have been bigger (for their age). It was really difficult (Karin, first interview, 12 January, 2016).*

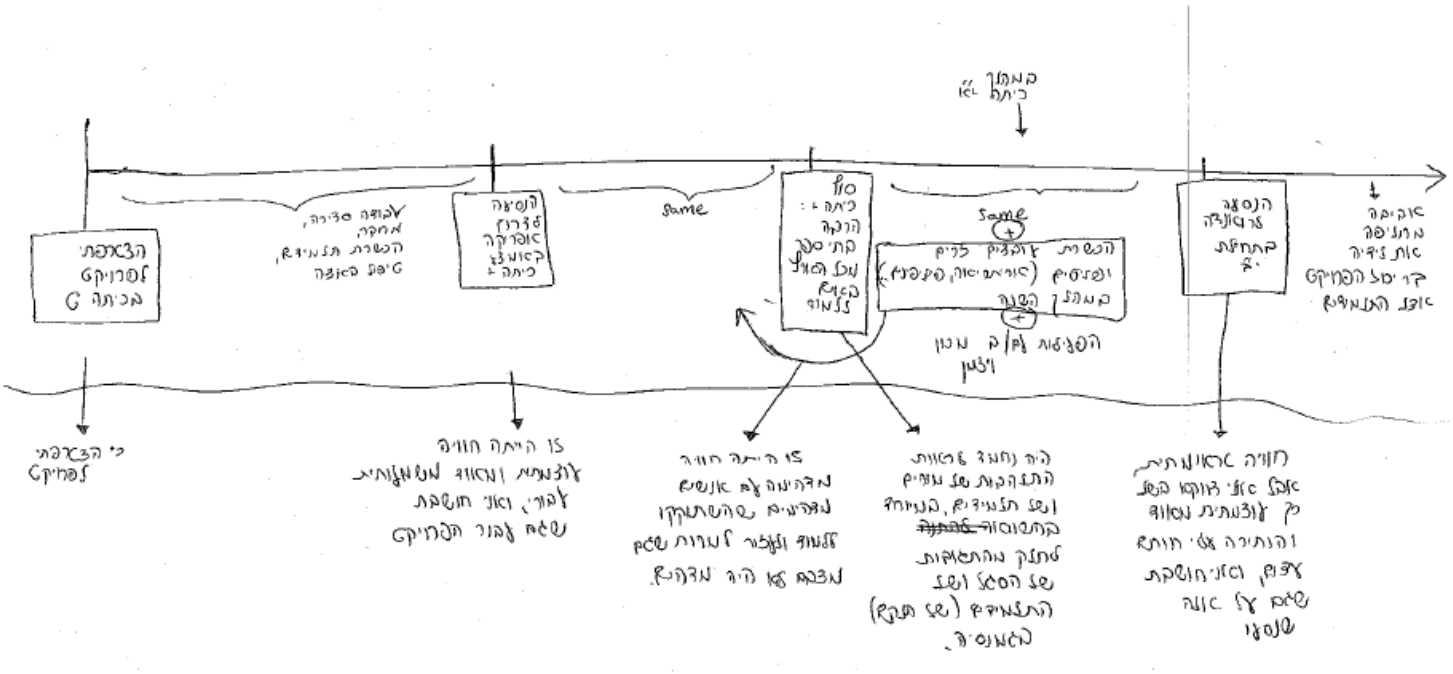


Figure 7. Karin's map of critical events

Apparent in these excerpts is that witnessing the harsh living conditions in Rwanda in first-hand, was obviously very difficult for Karin. Also evident, is Karin's tendency to focus on the care-based emotions, like empathy and a true feeling of sorrow for the people in Rwanda when considering the issue. Upon returning from Rwanda, Karin expressed her desire to quit the project. The trip was simply too much for her to go through without proper preparation. Eventually, she decided to stay and keep acting to resolve the issue of malnutrition because she recognized the issue as too urgent and important and felt accountable to help resolve it. When asked how the trip affected her actions as a participant in the project, Karin said:

*It made us realize that this is really urgent and existing and it is not something that you can postpone [acting on it] because people are dying from it, now! We saw kids in a really bad physical state. For me, personally, it was really difficult, but for the project, it really gave us a boost in terms of understanding how we need to act and also in terms of understanding the importance of [what we are doing], and even if it won't work, we still need to try because the cause is important. (Karin, second interview, 7 April, 2016)*

Again she is focusing mostly on the human aspect and on care-based considerations of the issue. By focusing on the care perspective where empathy and concern for others were the central features, Karin's argument relied more than anything on emotive reasoning patterns and rhetoric. Having able to employ these feelings mediated Karin's course of action on the issue of malnutrition in under-developed countries. This is a similar reasoning process to the one Yonatan used in the previous chapter. Like Yonatan, Karin wiliness to act on the issue was based on emotive considerations, which were amplified by directly experiencing and witnessing the humanitarian issue she is trying to solve (Fig. 8).


Figure 8. Access to the domain is increased by experiencing real humanitarian issues in first-hand

In the same sense, experiencing the humanitarian issue in first-hand also helped Karin to fully grasp the complexity of the issue she is trying to solve. Take for example the way she explained how current humanitarian aid attempts are failing in the long term and how it affects the citizens of Rwanda:

*All of those U.N. food containers, which we saw everywhere, by the way, I know how this ends. We met a physician from Congo who told us that they use UNICEF formula for babies to treat malnourished kids. But now, they ran out of the formula and kids are dying. So, this (type of aid) can't be considered as long term solutions. You run out of money, you run out of the formula, kids are dying. So…when we talk about*

*expendable and renewable resources, ours is truly renewable (Karin, first interview, 12 January, 2016)*

Here, Karin showed a critical understanding of the issue that relied on the appreciation of the social, political, and economic dimensions of the issue at hand. These lenses shaped how she talked about the project, and they were made available to her as a result of her participation in the trip to Rwanda. She then leveraged this critical understanding to legitimize the Spirulina project's actions saying that in contrast to the U.N. aid, their method is renewable (Fig. 9).


Figure 9. Access to the domain is in increased by the development of multifaceted critical understanding of the issue

***Experiencing and understanding humanitarian practice.*** What was also similar between Karin's and Yonatan's narratives were the ways in which both described how dealing with actual challenges and difficulties that humanitarian aid workers could face, led them to understand the practice of actual humanitarian help and also to the realization that solving a humanitarian issue is challenging. Coming back from Rwanda, it was very clear to Karin that solving the issue of malnutrition might be a much more difficult task than she had originally conceived. She recounted the different barriers she faced in detail, starting from technical difficulties like the conditions at the Rwandan schools and struggling to maintain a long-distance communication, and ending with cultural barriers like language differences and behavioral norms. All of these barriers made effective communication with Rwandan students especially challenging. While Yonatan regarded these difficulties as an opportunity to learn from student's mistakes and to find ways to improve their practice, for Karin it only added more pressure to the already overwhelming experience, to the point that, as mentioned earlier, she wanted to quit the project upon returning home.

*I remember coming back [from Rwanda] and being in shock that everything here continues as normal since everything back there was so difficult and so different. I guess it's just two different worlds. For me, I thought it would make me more engaged*

*in the project…but it was actually so difficult that I find myself deterred from anything that has to do with Rwanda and the project. (Karin, second interview, 7 April, 2016)*

Karin struggled to maintain a positive attitude towards the project after witnessing the harsh humanitarian conditions in Rwanda and after experiencing multiple technical and personal struggles. It was simply too difficult for her. What made her to eventually stay in the project and to continue to exercise the practice of humanitarian aid workers, even if less engaged than before, was the sense of urgency and acuteness of the issue. She explained:

*Children are dying. I don't think that there's a more noble and important cause. So, even if we are wrong and even if we fail, I think it's worth the try. (Karin, second interview, 7 April, 2016)*

In this quote, and after she explained candidly just how experiencing the practice of humanitarian aid workers was so difficult for her, Karin accepted the fact that the students who participate in the project might be wrong with their approach to acting on the issue. However, note that her experiences are not framed in the past but are expressed as an alive and continuous evaluation. Karin could have quit the project, but instead, she decided to stay. It was the urgency and the importance of the issue that provided context for her commitment to the project and maintained her sense of accountability and her willingness to act. This sense of urgency was made available to her through her trip to Rwanda and specifically through experiencing and understanding the practice of a humanitarian aid worker, which altogether provided for a greater access to the domain of the Spirulina project (Fig 10).

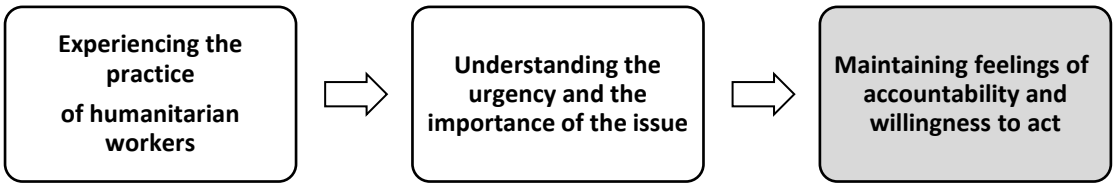


Figure 10. Access to the domain is allowed by fully experiencing the practice of humanitarian workers.

***Experiencing complex open-inquiry learning.*** From the onset of her first interview, Karin exhibited explicit distaste to school science. She recalled her experiences as a

science student in her lower secondary studies, where science is a compulsory subject, and explained candidly how her participation in the science classroom was constrained by limited access to the domain and positioned her engagement in school science in sharp contrast to her participation in the Spirulina project.

*In the Biology classroom, you mostly learn about processes and materials, but you learn from the textbook and you don't actually see it. And when you conduct an experiment, [teachers] hand you a paper with instructions and all you need to do is to follow them. It's really not interesting…Here [in the Spirulina project], you learn because it is interesting so you have the motivation to learn. You learn through research, through asking questions, through instructing others, which makes it a lot more interesting. (Karin, first interview, 12 January, 2016)*

In her critique, Karin said that her Biology lessons mostly did not align with authentic open-inquiry methods or context-rich scientific explanations. Instead, her inquiry experiences were typically limited to performing confirmation labs, in which students mostly followed a "cookbook-style" laboratory protocols. In this type of guided inquiry activities, the inquiry skills are partly teacher-controlled. In contrast, participating in the Spirulina project was more appealing to her because it allowed her to develop her own research questions and it was framed around an outcome in science that mattered to her, finding a solution for global malnutrition, which made the process of inquiry more interesting and motivating. She later elaborated about her school science inquiry experiences.

*We did this experiment where you shred a potato and you add some sort of substance to it and you need to wait and see the color of the potato change, but they [the teacher] don't tell you why we are doing what we are doing. It is like "just do it, just follow the instructions" and it is simply not interesting. (Karin, first interview, 12 January, 2016)*

Not only did she find her science inquiry experiences as not interesting, but she also struggled to make the relevant connections between basic science concepts and the lab activities she participated in. It appears that Karin was looking for a more authentic and contextually rich science experience, which she could not find in the science

classroom. At one point during the interview, Karin shifted the focus of the interview to reflect positively on the one-day inquiry activity that was given to the Spirulina project's students at the teaching laboratory of the Science Teaching Department at the Weizmann Institute of Science. This activity is also marked on her map of significant and meaningful events (Fig. 7), which signifies its meaningfulness to Karin.

The Inquiry activity was a separate activity given to the students as a way to enrich the scientific element of the project, and not a feature of the Spirulina project's setting in itself. Nonetheless, when crafting Karin's narrative, I decided to include Karin's telling of the activity because of her strong emphasis on the activity and because it explains how Karin found her unique way to engage in and with science and sheds light on the way Karin developed her identity as a participant in the Spirulina project.

Karin was a very active participant in the inquiry activity. She asked numerous questions during all stages of the activity, made sure with the instructors that each lab procedure was performed correctly by her, and even helped other, less engaged students to complete their procedures. Karin's experience in the inquiry activity reflected what she sought of science - it was science that emerged from engagement within meaningful, contextually rich framework that was relevant to her life. When I asked her what was so appealing to her in the activity, she contrasted it with her school science experiences, saying:

*They [the lab instructors], explained the thinking behind the experiment and they also let us talk. When we added from our experience, they listened to us. With our teachers, it is not like that. With my science teacher, it wasn't like that. And there was also a purpose. With the potato experiment, you know that the color will change to red. Here, we didn't really know what was going to happen. It was a real inquiry. (Karin, first interview, 12 January, 2016)*

Note how she finds it important that she and her peers were considered as meaningful contributors to the process of the inquiry activity and that the instructors consulted them throughout the activity. I then asked her what made it a '*real inquiry*', and she said:

*It was real because we didn't know what the result is going to look like. We guessed and assumed from our own experience of growing the Spirulina that the color [of the*

*Spirulina] is a good indicator for her growing rate, but we didn't really know if it was true. (Karin, first interview, 12 January, 2016)*

Both of these quotes show how having access to real scientists, as well as the structure of the inquiry activity itself, provided Karin with access to authentic scientific tools, thoughts, and experiences, which as a result provided for a greater access to the domain. The diverse experiences that were afforded to Karin in the context of an open inquiry activity offered her access to learning that differed significantly from the closed nature of school-based science. When she saw that the results supported the students' hypothesis and demonstrated a direct correlation between the Spirulina solution's color and protein content, it gave legitimacy to the students' own method of Spirulina cultivation. Also, now being confident with the proved efficiency of the students' method rendered her more competent.

Karin used the new resources that were afforded to her by the open inquiry activity to frame science in ways that fit the goals of the Spirulina project (i.e. solve the issue of malnutrition) – it not only provided the purpose for the investigation but also as a validation tool for the students' actions.

**Integral Roles**

***Karin as an Instructor.*** When asked to recall the meaningful moments from her participation in the Spirulina project, Karin immediately started to talk about the first instruction she gave to other students, saying that she first was "very afraid to stand in front of a crowd"**.** Over time, and overcoming her fears, it became the role she most identified with. In her map of critical events, Karin used the words *to teach* or *to train* when describing most of the events (Fig. 7). Most of her efforts in the project were put to advance her lecturing skills, a goal that she deemed as very important. She continuously stated that her commitment to instructing others provided a stimulus for her to deepen her own knowledge in the subject and she described the importance of learning the material so that she could instruct other students in the Spirulina project.

*I think that this is the best way to understand the material, because, if you understand it then it means you can explain it. And I'm not sure that students who study biology can explain the experiment [the conducted]. But we can. (Karin, first interview, 12 January, 2016)*

This closely parallels an idea expressed in the pedagogy of the Brazilian educationalist Paulo Freire (2000). He proposed a teaching technique in which both the teacher and the student are able to learn together while working side by side, thereby making teaching a two-way process. Interestingly, she does not think that school-based science can permit the same process, stating that while she feels that she is sufficiently knowledgeable in the context of the Spirulina project to instruct others, she thinks those who study Biology can't do the same task.

Instructing other students is an essential part of participating in the Spirulina project. In the school issued flyer describing the project, the headline read: *"Students teaching students about Spirulina algae"*. The flyer was written in a frequently-asked-questions form, showing a list of questions and below them the corresponding answers (Appendix A). One of the questions read: *"why don't you assist with food donations?"* to which the answer was*:*

*"The idea is to transfer the knowledge [like in a relay race], so that others could teach more people, instead of just taking care of themselves. Also, we learn a lot from this process and we enrich ourselves." ("Students teaching students about Spirulina algae", school-level promotional material)*

Karin's words reflected the same notion, describing the personal learning potential when acting as an instructor, but she also added a dimension of personal sense of accountability for her role as an instructor. When I asked her why it was so important for her to learn about the subject, she said:

*Because we want to teach others, and there is no way to teach others without knowing it thoroughly. (Karin, first interview, 12 January, 2016)*

As an instructor, Karin filled an integral role that she could identify with and that was distinctly part of the discipline that she learned about. Here, Karin makes a shift from explaining how she benefited from the role of an instructor to describing her need to master the skill of the instruction. It was not only important for Karin to learn more just for the sake of learning, but she also wanted to expand her knowledge in the

subject because she felt accountable to fill the role of an instructor to the best of her ability.

***Karin as a researcher.*** When giving instructions, and when she was asked to introduce herself to a new audience, Karin always found it essential to position herself as an outsider to school science by clarifying that she is not, in fact, a science student. However, in her interview, she placed more focus on the research part of the project than any other participant. In her map, for example, she marked the period between when she joined the project to the end of her 10$^{th}$ grade with continuous research, positioning herself within the scientific research of the student's cultivation method [Fig 7]. Multiple times Karin positioned herself as an individual who was knowledgeable and who gained her knowledge through *primary* (e.g., correlational studies) and *secondary* (e.g., internet searches) research. To understand how Karin filled the role of researcher, I first share an extended transcript excerpt taken from the lecture Karin gave to teachers in Israel. She opened her lecture by saying that she will present "the scientific part of the project". In her lecture, in an attempt to give legitimacy to the students' actions, she presented an argument for the use of Spirulina as a potential solution for malnutrition.

*The Spirulina exists for more than 3.5 billion years and it grows naturally in water reservoirs with high carbon content, which are mostly located in South-America and Africa. The biggest advantage of the Spirulina is that it contains 60-70 percent protein, depending on the quality [of the Spirulina]. And it's not just proteins, it contains all of the amino acids… One out of nine kids in the world suffers from malnutrition. In Africa, one out of four kids world suffers from malnutrition. Malnutrition is the number one cause of death for children under the age of five. If you consume Spirulina in adequate portions, which are 2-5 grams for a child and about 10 grams for an adult, you can see significant improvement within a week and two months the malnutrition can be completely gone (Karin, Student's instruction to teachers, 8 Dec, 2015)*

Here, Karin exerted herself as a researcher through appropriating ways of discourse, ideas, and practices of a scientist. Her lecture was rich with references to relevant scientific data fitted to the context, drawing upon a range of sources. She started by

describing in detail the nutritional value of the Spirulina, mentioning the amino acid composition of the protein source. She then continued by presenting the necessity of the Spirulina-based nutrition in under-developed countries. For this part of the presentation, she curated statistics taken from the "World Food Program" website (World Health Organization, 2007), and finished with a scientifically backed justification for the use of Spirulina as a potential solution for malnutrition. She also felt accountable, as well as found it meaningful, to be up-to-date with the recent developments and data in the context.

*The data always changes and there are new researches. So yes, it is a serious project. We don't just come and instruct. It is more than that. (Karin, first interview, 12 January, 2016)*

These elements are meaningful because they show that as a researcher, Karin not only asserted her knowledge about science but that she also appreciated science by consistently using scientific knowledge and practices as a way to legitimize the students' actions. This notion was also evident during a question-and-answer session between the teachers and the students when one teacher asked the students how they can assess the protein content of the Spirulina solution. There were four students present, including Karin, but it was Karin who jumped first with her answer. Recalling her participation in the open-inquiry activity, she answered:

*"We tested it at the Weizmann Institute, and what we found was that the greener the Spirulina is, the higher the protein content" (Karin, Student's instruction to teachers, 8 Dec, 2015)*

What matters here is less the accuracy of her response, but the fact that she exhibited considerable confidence to volunteer her scientific explanation to an authentic audience, which was backed by primary evidence that she and other students had generated. Here, again, she used research and research-based evidence as a way to legitimize the student's method. Thus, filling the role of a researcher in the Spirulina project may have encouraged Karin to more centrally incorporate science into her practices, for science provided legitimacy for her and her peers' actions.

**Opportunities for self-expression**

***Alignment with personal values.*** In a similar way to Yonatan, Karin found in the project an outlet for her own personal values. She openly admitted that she would probably not have joined a strictly scientific project and that she joined mainly for the humanitarian cause, saying:

*If it was only about growing algae, I don't think that I would have joined and I guess the same goes for the other students. (Karin, first interview, 12 January, 2016)*

What was appealing to Karin was that the project's declared goals aligned with her own perceptions of morality and values. For example, recall her quote appearing in the *access to the domain* vignette:

*Children are dying. I don't think that there's a more noble and important cause. (Karin, second interview, 7 April, 2016)*

She could easily identify with the issue and the cause, which she perceived as acute and urgent, accordingly. As a consequence, this made her a productive participant in the project. To reaffirm how Karin's identification with the cause affected and motivated her participation, consider the following excerpt in which Karin found it essential to make the point that the cause of the project is important by comparing her own life to the lives of those she is trying to help to:

*When we came back from Rwanda, I had a Math test that I was really stressed about. There's a song by Sia, she sings "some people really have problems", and it is so true. So, failing a math test is a problem, but not like not having anything to eat. (Karin, first interview, 12 January, 2016)*

Karin expressed a very similar notion in an article printed in Yediot Aharonot newspaper (Savir, 2014) when she said :

*Being part of the project reminds me how lucky I am to be born in a place with possibilities and opportunities, and how twisted is a reality in which there are people*

*who have nothing to eat. (Karin, Printed article in Yediot Aharonot newspaper, 26 December 2014)*

In both of these quotes, Karin expresses her empathy by focusing on the experiences that she, as a member of an advantaged group, experienced in relation to others, disadvantaged people's deprivation. Leach et al. (2002) have explored how members of advantaged groups attempt to either minimize or ignore completely their own privilege. They argue that before the promotion of social equity can occur, not only does the advantage must first be recognized by members of the advantaged group, but it must also be accompanied by a pro-social feeling, such as empathy, guilt, or sympathy. In that sense, Karin's ability to recognize her advantage and also express empathy towards those who suffer from malnutrition imply at her level of moral identification with the cause.

In her time as a participant in the project, Karin had experiences where she not only found and pursued her passion to "impact the world" in a way that aligned with her own values, but she also felt that she was a part of a caring community in which her values and what she perceived as the right thing to do were perceived as the normative form of action. She spoke about this during one of her interviews to "Maariv Online" news website (Weitz, 2015):

*Being part of the project makes me want to become a better person, and I think that this is what brings [the participating students] together. The people I meet through the project are people who are trying to make the world a better, fairer, more equal place. Being surrounded by this company fills me with optimism. (Karin, Interview to Maariv website 19 February 2015)*

Karin's sense of belonging and relatedness to her peers was clearly important and promoted her engagement in the project. Her sense of relatedness was not limited to being supported but was directed by the feeling that her values, and the social and political actions that she considered as important, were rendered normative by her peers.

***Using personal skills when instructing***. The notion of specific roles can be seen as confining to what students can do within a particular activity. However, filling the

role of an instructor provided Karin with opportunities for self-expression. In the context of the Spirulina project, instructing others allowed Karin to put something of herself into the practice in the form of personal skills. For Karin, it was using a flexible form of science information, that of drawings of scientific diagrams, that allowed her to introduce her drawing skills from another context into an activity involving considerations of the scientific aspects of a phenomenon. This use of skills came most handy during instructions to Rwandan students and farmers, who struggled with language barriers. In the summer between Karin's 11$^{th}$ and 12$^{th}$ grade, and before her trip to Rwanda, a delegation of Rwandan farmers came to her school in order to learn from the students how to cultivate the Spirulina. Karin presented a very quick introduction in which she explained to the farmers about the photosynthesis concept and why the Spirulina needs sunlight for growth, during which she carefully drew a diagram showing the sun rays affecting the Spirulina culture indicating the positive effect by drawing the sun with a smiley face (Fig. 11). She then explained how in very warm weather, water from the medium could evaporate, which would require the farmers to add water to the medium. She emphasized the evaporation effect in her diagram by drawing wavy lines coming out of the Spirulina bottle.
Karin used her drawing skills as a way to overcome language barriers also while giving instructions in Rwanda and in South-Africa.

*After we realized that they don't understand English, we started to draw [the instructions]. (Karin, second interview, 7 April, 2016)*

In an interview she gave to the teen news website "Frogi" (Daabul, 2015), Karin elaborated on how she used this technique, as she explained how she instructed South-African students in her previous delegation, as she said:

*We presented them with a huge amount of material in a very short time and we didn't do it in conventional ways like in presentations and summaries because not all students even understood English. Instead, we did it by drawings. We drew the earth and where there is light and where it is dark and what you should do with the Spirulina. (Karin, Interview to Frogi website 24 February 2015)*

*Figure 11. Karin adding hand-drawn diagrams to her instructions*

She also expressed her satisfaction when she saw that this method of instruction, through drawings, was supportive of the foreign students' learning. In an interview she gave to the Al-Monitor website (Canetti, 2015), she described her trip to Cape Town, South Africa, as follows:

*Some [of the students we instructed] came from distant, poverty-stricken areas. It was inspiring to teach them and see how we can help. Not everybody spoke English, so we communicated through drawings and gestures. Within two days we saw how they pass on to others what they learned, and that was really awesome. (Karin, Interview to Al-Monitor website 22 July 2015)*

Karin's drawings allowed her to utilize, within the Spirulina project, drawing skills she had already possessed. In this process, Karin drawings served as an outlet for her self-expression. For her, drawing graphical representations of different scientific concepts such as photosynthesis, water evaporation, and earth's rotation served as a way to communicate scientific topics using a graphical medium. In that sense, this form of self-expression was welcomed and Karin's drawings were recognized as a means of enhancing instruction outcomes and she repeated this technique when she felt it was needed.

### Chapter summary

Karin's narrative had many similarities with Yonatan's narrative (for a cross-case comparison, see Table 2 in the discussion chapter). Like Yonatan, her access to the domain was increased by having the opportunity to directly witness the humanitarian situation in Rwanda. However, for Karin, this experience was also traumatic and lead to her desire to quit the project altogether. Karin demonstrated an emotive reasoning pattern which directed her willingness to act on the issue, and her willingness, in turn, was amplified by directly witnessing the humanitarian issue she is trying to solve. In addition, directly witnessing the humanitarian issue also helped Karin to grasp the complexities embedded in the humanitarian problem of global malnutrition and required her to consider the multiple dimensions of the issue. Experiencing the practice of humanitarian workers also gave Karin greater access to the domain. It brought up the sense of urgency of the issue and allowed Karin to maintain her feeling of accountability to resolve the issue.

What was unique about Karin's narrative was her appropriation of science and the scientific method. Participating in an open inquiry activity addressing an, what Karin regarded as, important and relevant question, offered Karin not only a greater access to the domain but also allowed her to find new ways to engage in science that were not available to her before. Karin was afforded two main roles in the project, that of an instructor and that of a researcher. As a researcher, she found ways to incorporate science into her life by adopting scientific discourse and practices as a way to give legitimacy to hers and her peers' actions. As an instructor, Karin found it essential to improve her skills by deepening her knowledge on the subject she is instructing and felt accountable to give good instructions to others.

There were several opportunities for Karin to express herself and to incorporate herself into the practice. She found the project's goals aligned with her own values which made it easier for her to relate and feel a sense of belonging to the project. Finally, by adding carefully drawn scientific diagrams to her instructions, Karin found a way to express herself in a way that was connected to her role as an instructor.

## Discussion

The primary purpose of this study was to understand and make sense of the ways in which two students who participated in a school-based SSI project, the Spirulina

project, came to take up practice-linked identities, how such identities were made available to them and how they practiced said identities in an SSI setting. For this purpose, a student-led SSI themed project was examined. The project operates on a school-level and involves students trying to develop a simple and cheap cultivation method for the cyanobacteria Spirulina as a protein-rich dietary supplement, aimed at underdeveloped countries.

Following Nasir and Hand (2008), I suggest that three resources related to practice-linked identities - access to the domain, integral roles, and opportunities for self-expression - are central to understanding students' participation.

This research effort attempted to achieve a better understanding of aspects of individual participation and identity construction by exploring the narratives of two case study students, Yonatan and Karin. In order to make sense of how students practiced and built their identities through participation in a socioscientific project, I collected and analyzed multiple data sources including phenomenological interviews, observations, and document analysis. Additional attention was put forth to examine how having practice-linked identity resources supported students activism in science education

Findings reveal that in the Spirulina project, practice-linked identity resources were available for students to utilize and supported students' identities as participants in the Spirulina project (Table 2). Through access to the domain, students were afforded to experience firsthand the humanitarian issue in underdeveloped countries in the context of global malnutrition. This was probably the strongest resource that was afforded to the students as it had connections to most parts of both students' narratives. Additionally, students who participated in the field trip to Rwanda did not experience it as observers or as bystanders, but they were actively involved as humanitarian practitioners trying to resolve the issue of global malnutrition. They interacted with local students and farmers and instructed them on the Spirulina cultivation method, they met with government officials in order to secure the goals of their visit, and they gave each other feedback about their own instructions. Findings suggest that having such wide access to the domain of the Spirulina project initiated and motivated students' willingness to take action in the context of global malnutrition.

Yonatan and Karin also had opportunities to fill important roles, both to themselves as well as to the whole group and to the project itself. The roles that the students took up

were primarily that of instructors and that of researchers. It appears that both Yonatan and Karin identified more with the role of an instructor, as both of them felt more accountable for improving their skills as instructors and aspired to be competent instructors.

Within the practice of the Spirulina project, both Yonatan and Karin had opportunities to express themselves and to make a unique contribution to the project. These opportunities were readily available for the students mainly because their personal values and vision of the world were reflected in the ideology of the Spirulina project. They felt valued for who they are and for their ideas. This form of identification allowed Yonatan to consider a possible future trajectory in a science related field. For Karin, she felt valued for her specific skills as an instructor, which included drawing scientific diagrams.

The cases of Yonatan and Karin are interesting to study together because their experiences in the Spirulina project were unique and diverged from one another. Yonatan is a science major student who found humanitarian value and personal purpose in his participation in the project, but who did not care much for the scientific elements and practices of the project. Karin is a non-science major student who appreciated the scientific elements of the project and who took upon herself the different practices of a scientist. Yet, in many ways, their experiences also parallel each other (as well as the experiences of the two other students who participated in my study, Dan and Sanaa), as both of them found similar identity resources as valuable to their engagement in the project, and as a result, they were able to develop their practice-linked-identities (Table 2). In addition, both of them shared similar narratives in telling what motivated them to take action on SSI.

In the following section, I will revisit findings from both cases and take a closer look at the students' practice linked identities. To answer my research questions, I will describe the different identity resources that were available to the students and how these resources supported their participation in an SSI project. I will also discuss the relationships between the identity resources that were made available to the students and their willingness to participate in a student-led action to reduce or eliminate global malnutrition. The discussion of the findings will be arranged into three sections: *the role of experience, significant roles, and ideational and relational resources.*

**Table 2. Cross-case comparison between Yonatan's and Karin's individual narratives**

| Identity resources | | Yonatan<br>11th-grade student, majors in Computer Science and Physics | Karin<br>12th-grade students, majors in Arabic Studies and History |
|---|---|---|---|
| **Access to the domain** | **Similar sub-themes** | • **First-hand experiences of humanitarian issue** allowed for the development of emotive reasoning patterns which lead to willingness to take action<br>• **Experiencing and understanding the practice of humanitarian aid workers issue** increased the feeling of competency | • **First-hand experiences of humanitarian issues** allowed for the: 1) development of emotive reasoning patterns which lead to a willingness to take action, 2) development of a multifaceted critical understanding of the issue<br>• **Experiencing and understanding the practice of humanitarian aid workers** brought up the sense of urgency and maintained her feeling of accountability |
| | **Differing sub-themes** | • **Access to experts** allowed for the learning of knowledge and skills as well as to individual and group competency | • **Experiencing complex open-inquiry learning** allowed Karin to frame science in ways that fit the goals of the Spirulina project and finding new ways to engage in science |
| **Integral roles** | **Similar sub-themes (no differing sub-themes were observed)** | • **Instructor:** perceived as an authentic role with a high-risk performance association which leads to an increased sense of accountability and willingness to act<br>• **Researcher:** perceived as too simple and framed in juxtaposition to the role of instructor, which ultimately leads to its reduction | • **Instructor:** a two-way construct of teaching - teaching others as an opportunity to learn, and learning as an opportunity to improve teaching skills<br>• **Researcher:** adopting scientific discourse and practices as a means to legitimize the students' actions |

**Table 2. Cross-case comparison between Yonatan's and Karin's individual narratives (continued)**

| Identity resources | | Yonatan<br>11th-grade student, majors in Computer Science and Physics | Karin<br>12th-grade students, majors in Arabic Studies and History |
|---|---|---|---|
| **Opportunities for self-expression** | **Similar sub-themes** | • **Personal values**: Allowed Yonatan to connect his own experiences and values to larger social issues | • **Personal values**: allowed Karin to: 1) connect her own experiences and values to larger social issues, and 2) be a member of a caring community |
| | **Differing sub-themes** | • **Personal professional aspirations:** finding a desire for a science related career and closing the gap between his actual and designated identities | • **Using personal skills when instructing**: drawing graphical representations of different scientific concepts were recognized as a means of enhancing instructional outcomes |
| **Students with similar narratives** | | **Dan** – 12th-grade science student who majors in physics and computer science. The most senior student and appointed CEO of the project. Identifies himself as a "realist, a person who sticks to the facts". He said that his primary motivation is to instruct others and that he "really doesn't care what is in the Spirulina or how to grow it". He is currently considering ways to monetize his knowledge in Spirulina cultivation and considering starting his own Spirulina business. | **Sanaa** – 11th-grade student who is "interested in science and enjoys learning science", but who is not majoring in any scientific subject. Sanaa identifies herself as a Palestinian-Arab and as a minority in her country.<br>She considered her participation in the project as contributing to the reduction of global and local social injustices. She felt valued filling her role as a researcher in the project and used scientific inquiry as a way to legitimize her and her peers' actions in the project. |

**The role of experience**

During their practice in the Spirulina project, students were afforded meaningful experiences across several dimensions. Students had wide access to the domain. Experiencing the humanitarian conditions in Rwanda first hand, allowed the students to develop emotive reasoning patterns that guided their course of action. This way of reasoning is characterized by an inclination to focus on the human element of issues and is consistent with the employment of pro-social feelings such as empathy and care (Sadler & Zeidler, 2005). Both Yonatan and Karin exhibited emotive reasoning patterns by employing empathy and feelings of concern for the well-being of Rwandan citizens (examples of emotive reasoning pattern can be found in Table 3). It was these feelings that guided their actions and motivated them to invest effort and time in order to reduce global malnutrition. It appears that their feelings, though present to some extent from the beginning of their participation, were enhanced after their trip to Rwanda. Several researchers have stressed the importance of using emotions when considering moral and just ways of action (Berkowitz & Simmons, 2003; Sadler & Zeidler, 2005; Zeidler & Keefer, 2003). Zeidler and Schafer (1984) explored how students form their moral judgment in the context of environmental and social SSIs. They concluded that students' moral reasoning is influenced in part by the setting or the context of a moral dilemma. Turiel (1998) elaborates on the development of pro-social feelings like empathy and sympathy with accordance to social, emotional, and personality development. He argues that children form their own moral judgment through social experiences, which include the understanding of moral constructs such as justice, human rights, equality, and welfare. The main point is that experiences with various social interactions appear to mediate students reasoning patterns.

Results from my study are consistent with Zeidler and Schafer's (1984) and Turiel's (1998) investigations. Here, students' experiences affected their reasoning patterns and rendered them primarily emotive. The context of the issue that the students chose to act upon in the Spirulina project was possibly more extreme and socially charged than other SSIs, and Yonatan and Karin were given an opportunity to further explore the issue by directly witnessing the extreme humanitarian condition in Rwanda. As a result, they generated arguments to defend their actions which are mostly built on emotions that included care, empathy, and responsibility. Further, it is suggested that a focus on a more social and sensitive dilemma, one that provoked their feelings of

care and empathy, motivated their willingness to take action and try to resolve the issue of global malnutrition**.** It is important to add, that in Karin's case being exposed to such extreme experience was perhaps personally difficult to the extent that she described the experience as traumatic and desired to quit the project.

Table 3. example from students emotive reasoning patterns

| **Student** | **Example** |
|---|---|
| Yonatan | The people [in Rwanda], their lives are very different from ours. Suddenly, I realized that their happiness is different from our own – I am happy when I get a new computer or a PlayStation game. They are happy when they get water. All of a sudden, I started to realize that these gaps should not exist, and if I can do something to change it, then why shouldn't I? |
| Karin | People are dying from it, now! We saw kids in a really bad physical state. For me, personally, it was really difficult, but for the project, it really gave us a boost in terms of understanding how we need to act and also in terms of understanding the importance of (what we are doing) |

For Karin, the visit also assisted in the development of a multifaceted and critical understanding of the issue and she referenced multiple dimensions and stakeholders that are part of the dilemma. In that sense, having greater access to the domain by directly witnessing the conditions in Rwanda further contributed to her willingness to act as she used this understanding to legitimize the students' actions and the project's aims.

The trip to Rwanda also allowed Yonatan and Karin to experience and to understand what it is like to be a humanitarian aid worker. In that manner, they were afforded greater access to the domain by participating in day-to-day activities that take place in everyday life. Theories of situated learning argue that contexts for activities can either afford or constrain what learners can do and learn (Sadler, 2009). This perspective suggests that learning cannot be separated from the environments in which it occurs. In this kind of learning experiences, the learner takes part in authentic activities in which his/hers learning changes his/hers participation (Lave & Wenger, 1991). Viewed in this sense, learning is characterized by increasing competence in the activities. Both Yonatan and Karin had the opportunity to participate in authentic activities that mediated their participation in the project. For Yonatan, taking part in a humanitarian practice of in Rwanda allowed him to identify the strengths and weaknesses of his instructions. This understanding was expanded by sharing findings from instructions with other students which contributed to the development of Yonatan's competency in the practice of instruction.

A related point in Yonatan's case is that he emphasized his regular and sustained access to experts which further allowed him to participate competently. For Karin, participating in humanitarian practices prompted her understanding of the urgency and immediacy of the issue. In both cases, having increased access to the domain through participating in an authentic activity mediated the students' willingness to act. Whereas for Yonatan it was the sense of achieved competence that allowed him to feel efficacious to actively participate in an action on SSI, for Karin it was the feeling of personal accountability. Lee et al. (2013) argue that feelings of accountability are a necessary precursor for responsible action because it implies both liability and ownership for the action. In that sense, Karin's demonstration of accountability implies that her participation in humanitarian practices supported her willingness to act on the issue of malnutrition.

Karin's narrative demarcated the line between school-based science inquiry and authentic and co-opted inquiry experiences. Here, I use Jrene Rahm, Miller, Hartley, and Moore (2003)'s definition of authenticity in scientific inquiry. They argue that authentic science should reflect on a deliberative process between scientists, teachers, and students on how science activities should be structured. In that sense, Karin's experiences with school-based science inquiry activities were limited and constraining and resembled a closed inquiry process. For these reasons, she tended to position herself as an outsider to school science. On the other hand, participating in an authentic inquiry activity contributed to Karin's ability to engage in and with science in more than one way. First, she was afforded the opportunity to experience science that not only felt more real to her, but that was also tied to who she is and to her personal interest, and that was thus meaningful and relevant to her life. Second, she used the knowledge that she gained from the activity to legitimize her actions and to give them scientific validation, thus appropriating scientific evidence and claims and to her needs.

**Significant roles**

Appointing students to roles that matter made them a critical and an integral part of the Spirulina project. Nasir and Hand (2008) discussed how opportunities to take on integral roles were one of three elements of practice-linked identities. In the Spirulina project, students' roles were integral to the way the project functioned. The Spirulina

project afforded students to take roles that included increased opportunities for identification responsibility, putting them in charge of the project's success.

In both Yonatan and Karin's cases, they were given roles that not only mattered to them personally, but that also had a significant and actual impact on the project as a whole. Both students filled the same roles, that of an instructor and that of a researcher. For both Yonatan's and Karin, a central part of their roles as instructors seemed to be that they felt they were needed and both students felt highly accountable to improve their skills. For Yonatan, the instructor role carried actual weight, not just the appearance of impact or influence. He considered his success or failure in filling the role as crucial to the wellbeing of Rwandan citizens. This made the practice of instruction more authentic. In turn, the authenticity of the role impacted Yonatan's participation in the project as he felt accountable to improve his skills as an instructor and to keep trying to resolve the issue of global malnutrition. In Karin's case, improving her instruction abilities was important because it impacted other participants and the functioning of the project. For her, the sense of accountability for the practice of instruction mainly manifested her desire to learn more about the subject, in order to improve her instruction abilities. Barton and Tan (2010) have defined the process where students use their acquired knowledge as a means to shift positions, as a form of action taking and as a way for students to position themselves as 'science experts'. In that sense, instructing others was perceived by Yonatan and Karin as an endeavor that could possibly help to solve a problem.

Their stories diverge when they discuss their roles as researchers. For Yonatan, while the role of an instructor represented an opportunity for actual impact, the role of a researcher was deemed as less integral and was thus marginalized. For him, the scientific investigation into the cultivation of the Spirulina was too simple and lacking scientific rigor. For these reasons he had an already achieved sense of competency, and thus did not need to further improve his knowledge and skills as a researcher. Moreover, he tended to place the role of a researcher in juxtaposition to the role that truly mattered to him and that truly had an effect, that of an instructor. For Karin, the story is quite different. Even though she, like Yonatan, identified more with the role of instructor she still considered the role of researcher as integral to the project. She used the scientific practices as a means to position herself as a knowledgeable individual and as a way to legitimize her actions in the project. Accordingly, her lectures included the use of real-world data, scientific discourse, and scientific

representations. She shared her understanding about Spirulina cultivation with others in ways that were accurate and backed by evidence. Yet, even this role was interwoven with the role of instructor, as Karin crafted a comprehensive narrative around helping and instructing others as a motivation to expand her scientific knowledge and understanding. In other words, Karin embraced science as a means to advance change in the world. In that sense, it may be that the context of the Spirulina project promoted Karin's identification with the researcher identity by framing the notion of being a knowledgeable individual in science as a trait that benefits others. For Karin, this framing turned the experience of filling the role of a researcher from a strictly scientific experience to a more relatable and engaging experience.

By examining the roles that Yonatan and Karin filled, it is possible to extend the idea of practice-linked identities. In both cases, access to the domain, integral roles, and opportunities for self-expression in practice seem to be integrated within the role itself. In order for the roles to appeal to the students, the roles needed to grant access to the domain, be integral, and to contain opportunities for self-expression. The role of an instructor achieved these goals. It was perceived as most integral to the project's success. It granted students with access to the domain in more than one way. For example, in Yonatan's case, it was the feedback he got from fellow students with regards to his instructions that made the practice of instruction more transparent and thus allowed him to develop an understanding of the practice. For Karin, wanting to develop an expertise as an instructor demanded that she will have to thoroughly understand the subject of her instructions.

Both students were afforded opportunities to integrate themselves into the role of instructors. Yonatan, after realizing that his instruction method needed some improvements, suggested that using humor, for example, could promote his instructions. Karin created moments of self-expression in practice when she used her drawing skills to illustrate diagrams that were meant to elucidate complex scientific concepts. Her drawings not only carried an opportunity for personalization but were also recognized by the group as a legitimate tool to enhance instruction outcomes, thus encouraging Karin to explore the role of instructor. On the other hand, as researchers, both Karin and Yonatan had fewer opportunities for self-expression and, to some extent, less access to the domain. For a role to be considered engaging and appealing to Yonatan and Karin, it needed to incorporate the three elements of

practice-linked identities – granting access to the domain, being integral, and permitting opportunities for self-expression.

**Ideational and relational resources**

In the Spirulina project, there were numerous opportunities for self-expression in practice. Specifically, these opportunities were built upon ideational and relational resources which amplified the students' participation and engagement in the project. Nasir and Cooks (2009) define ideational resources as "ideas about oneself and one's relationship to and place in the practice and the world, as well as ideas about what is valued or good". In the Spirulina project, ideational resources included students' perspectives of a moral and just society as well as students' ideas about what they can do to achieve such a society. Both Yonatan and Karin described their motivation to participate in the project as having connections to their own personal values. As participants in the project, they were given an opportunity to connect their personal values to larger social issues, such as global malnutrition. Both described the cause of the project as urgent and as demanding our attention and both declared that if it was not for the humanitarian cause, they would probably not have joined the project. Their conception of what is morally and just thing to do is what guided their participation in the project. In that sense, Yonatan and Karin had access to ideational resources that supported their practice-linked identities.

Karin' opportunities for self-expression were also emphasized by having access to relational resources. Nasir and Cooks (2009) describe relational resources as "the positive relationships with others in the context that can increase connection to the practice". For Karin, having relational resources in the project allowed her to advance her knowledge, as she learned through instructing others and they were also the reason to learn, as she wanted to improve her instructing skills. Both of these elements were a result of social interactions between Karin and her peers. More importantly, the feelings of belonging and relatedness to the project and to her peers supported her participation. Furrer and Skinner (2003) argue that an environment that allows for supportive relationships and for students' perceived sense of relatedness to peers can contribute to their engagement. They, therefore, emphasize the importance of social connectedness. In that sense, for Karin, the relational resources were intertwined with the ideational resources, as having being surrounded by peers who share the same values as she, provided her with a feeling of comfort and support. It appears that

having such level of support, both ideationally and relationally, allowed for Karin's deep engagement in the Spirulina project.

The range of resources that Yonatan utilized during his participation in the Spirulina project, including ideational resources and other practice-linked identity resources (i.e. access to the domain, integral roles, and opportunities for self-expression), shaped his participation and his actions toward solving global malnutrition. The alignment of his values with the underlying ideas of the project allowed him to identify a desired career trajectory in science and he considered his participation in the project as a way to meet his own career and life aspirations. Sfard and Prusak (2005) made the distinction between one's 'actual identity' and 'designated identity'. The notion of actual identity consists of stories that narrate the present and the current state of affairs. The notion of designated identity consists of stories that narrate the future and the expected state of affairs. These stories describe what students perceive as possible or achievable for them. In that sense, learning is conceived as the process of closing the gap between one's actual and designated identity (Sfard & Prusak, 2005). Accordingly, Yonatan's negotiation of ideas about his future self can be viewed as a process of identity development. Yonatan crafted his narrative of his future self around the desire to help others through his knowledge in science, and through the knowledge that he intends to acquire. It appears that Yonatan's participation in the Spirulina project, and the following access to various identity resources, allowed Yonatan to close the gap between his actual and designate identities.

**Limitations**

This study has some obvious limitations. In order to answer my research questions and to understand the process of students' identity development, this study focused on a small sample of students. All students were high achievers who volunteered to enlist to the Spirulina project. Not examining a large number of students from a wider demographic range is a considerable limitation of this study. In addition, because of the small group of participants and qualitative nature of the data, general claims could not be made about students who participate in an SSI setting.

The retrospective nature of the interview, while beneficial for supporting a reflective process, is also a limitation. Recollection of events and their meanings for the participants may have been influenced by the passage of time (Metts, Sprecher, &

Cupach, 1991). The triangulation of data from these interviews with other data sources, such as observations of students in practice, as well the decision to interview multiple individuals, assists in reducing this limitation.

Another limitation of this study is that observations were conducted sporadically. Because of this, the study only captured a fragmented illustration of the students' identity work. When analyzing identity it is essential to conduct a long-term observation and analysis (Wortham, 2006). For this reason, this study focused on students' identity with relation to their practice, rather on their identity as a whole.

**Looking ahead**

Yonatan and Karin's cases represent the kind of identity development and support that may be possible when practice-linked identity resources were readily available for students to utilize (Fig. 12). However, the larger corpus of the students' group who participate in the Spirulina project include students with different experiences from Yonatan and Karin. Some struggle to continually invest time and effort in the project, and some even quit the project. It is important to consider cases where these resources are either less available or left entirely undesired by the students. In such cases, students' participation in a specific practice is expected to be marginal and less engaged, or they may cease to participate altogether. An interesting area for future research is to explore a wider variety of narratives of students who participate in SSI learning settings. Specifically, it would be interesting to explore newcomers' participation over a period and to include students who are less engaged in the research group. Illuminating students' experiences in a limited and constrained learning environment, and their subsequent marginalization, can advance our knowledge of students' practice-linked identity development in SSI learning settings. Hopefully, such investigation could allow for marginalized students to participate more productively in such settings in the future.

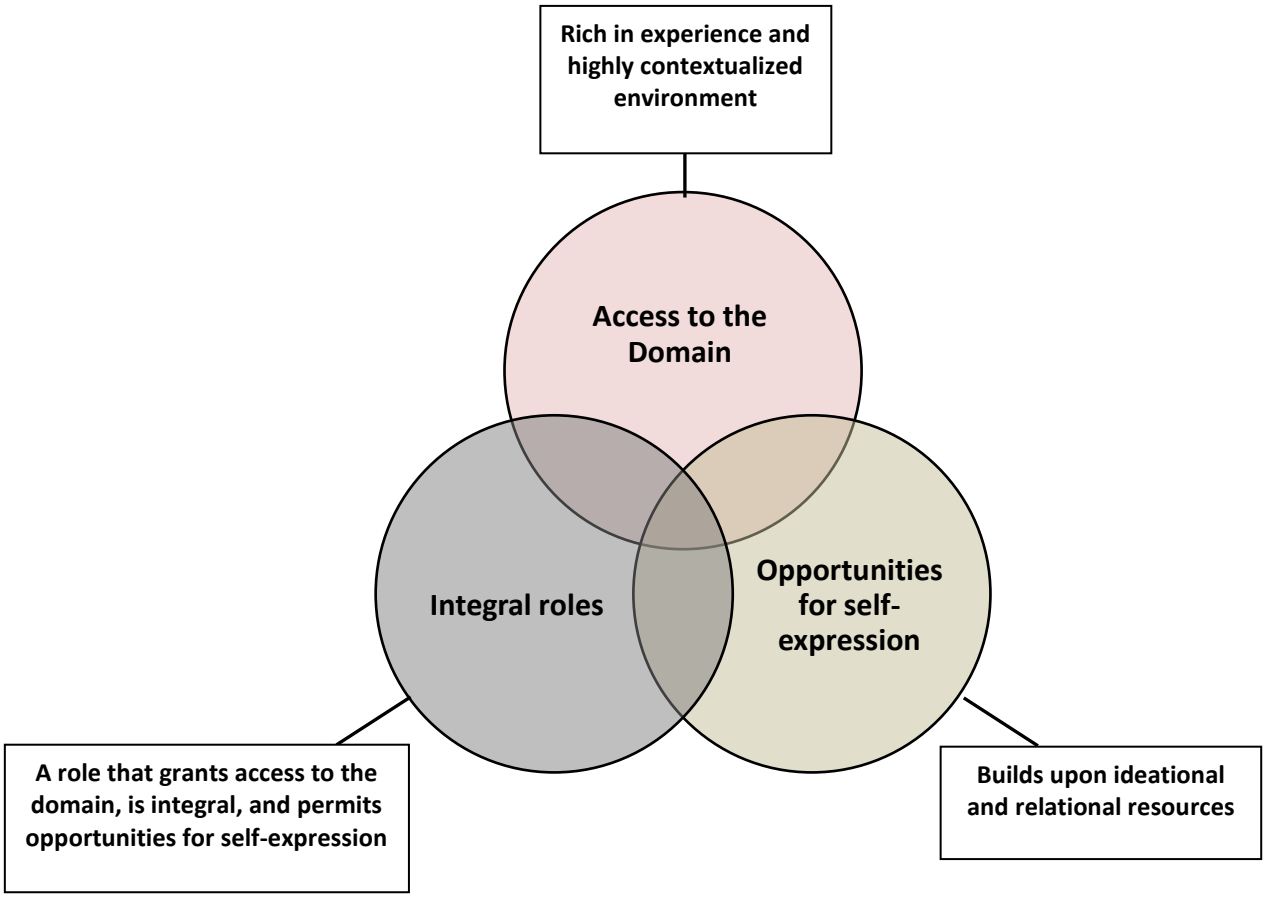


Figure 12. A summary of essential identity resources available for Yonatan and Karin in the Spirulina project

This study provided a glimpse of into a project in which high-school students participate in in-school inquiry activity for the better wellbeing of others in the context of an SSI. The project's setting was shown to be engaging for the participating students and this study has described the different identity resources that supported the students' engagement. However, the Spirulina project was a school-level organization and its setting and practices differed greatly from those of the traditional science classroom. Creating a learning environment that supports students' engagement is a practical challenge for teachers in the traditional science classroom (Nasir & Hand, 2008). Furthermore, the utilization of scientific knowledge for the wellbeing of others or for social progress is considered an integral part of science literacy and therefore should be represented in the science curriculum (Hurd, 1997)**.** A previous study conducted by the researcher and peers (Appendix B) examined the representation of such notions in the Israeli Biology curriculum. More specifically we analyzed the national Biology curriculum with the aim of examining if it can support

learning by inquiry of SSI. Findings from this analysis have shown that while there are explicit references to SSI education in the curriculum, it is not presented in an integrative manner with inquiry based learning methods (Machluf, Zafrani, & Yarden, 2015). Therefore, another feature to explore is students' participation in an inquiry learning unit in the context of SSI as it is practiced in the traditional science classrooms and, more specifically, how identity resources important for engagement are made available, or unavailable, for the students to utilize in such context.

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## Appendices

**Appendix A:** ***"Students teaching students about Spirulina algae"*****, a school issued flyer describing the project**

תלמידים מלמדים תלמידים מנושא אצות הספירולינה:

במסגרת הקשר בין הגימנסיה לבתי הספר היסודיים המזינים: תל נורדאו, היובל וגרץ, יצאה קבוצת תלמידים משכבות ט, י, יא וכן נציגי ז' ללמד את תלמידי כיתות ו', על הפרויקט המיוחד של האצות.

התלמידים צפו בסרטון, ערכו ניסוי: הסתכלו במיקרוסקופ,מדדו, שקלו והצליחו לשכפל את האצה בבקבוקים. בנוסף, שאלו שאלות והציגו תובנות מרתקות. לבסוף, עצבו את בקבוק האצה ששכפלו. כשחזרנו לגימנסיה תלינו את הבקבוקים במתקן השכפול.

כשתגיעו לבקר אותנו בחודש הבא – תראו את הבקבוקים....

מחכים ומצפים לביקורכם

מסתכלים במיקרוסקופ

מה הכאות המותרת לאכול?

תלוי במשקל ובגיל

האם אפשר שמציון האופרנ, הצבה תאלן את האלון האצלף ובלא בריא?

הצבה כפר כיום משאשת כתוסף תזונה, אך אחיכה משוק שבוה ולכן פיתחנו את אופל הגיוק הגול והצאין.

אפור אתה לא אסיעים מתרואת אוכל ?

הרצון להצמיר את התוכה (כאו באיכוע שלוחים) , שאחרים מצכותה וכלוחו לשאף אחרים ולא רק יגינו אתצאם. כאו כן, אנו יוצאים מהתלים הרמה ואלף מעשירים את עצמנו.

על מה למדנו היום:

הצה לאבאת לא רק בים

אשר באמצים משומים לעשות בחרים פיזיים

ברוך לחשוף על האחר ולא רק על עצמנו

מבית הספר ברש

מתקן פלואנסיה





היכן מפקים את הצבה?

ישנם פיזיקים מעצוים בחרום אחריקה ואסריקה.

ישנם פיזיקים מלאכותיים שבלנו בפואנסיה במתקן אוחף.

איך הצבה נראית?

בצורה ספירלה, ניתן לראות ברק מיקרוסקופ

כאה למן לוקח לפקף הצה?

תלאי הפיזיקן חשוקים לפיזיקה. יש לפאוך לסאסרטורה שאיות ואחה ולא בסבימות יוחיים עד שלושה הינ פקה.

האם יש עוד אפילות שאתה רוצים לחסוף את הצה?

עד היום התמקלו בחרום אסריקה.

בתכנון לעתיך הקרוב, נפתך ואתיופיה.

## Appendix B: Analyzing the Israeli Biology Majors' Curriculum in Light of the SSIBL Framework

## [1]Analyzing the Israeli Biology Majors' Curriculum in Light of the SSIBL Framework

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***Abstract***

The Socio-Scientific Inquiry Based Learning (SSIBL) framework, which was developed in the course of the PARRISE project, is based on four pillars which are integral to the SSIBL pedagogy: Inquiry-based Science Education (IBSE), Citizenship Education (CE), Socio-scientific Issues (SSI), and Responsible Research and Innovation (RRI). This study explores the extent to which the four pillars of SSIBL are addressed in the intended curriculum for $10^{th}$-$12^{th}$ grade biology majors in Israel, and assesses the constraints and challenges in realizing and implementing them in the classroom. Four curriculum related documents published by the Israeli ministry of education were analyzed: an overarching view document and three main modules. The results indicate that although all four pillars are addressed in the biology curriculum, some of their fundamental features are neglected. Also, the four pillars are not integrated in a coherent manner: while RRI and SSI aspects are mainly addressed in both the elective and core units, IBSE is exclusively associated with the inquiry unit, whereas CE is only rarely mentioned. We argue that the reason for the low level of implementation of the four pillars of SSIBL in the curriculum stems from the misalignment between the curriculum and the matriculation examination. Since not all the four pillars of SSIBL appear in the matriculation examination, teachers tend to not ignore them, for reasons of time shortness and lack of resources. These findings call for a reform in the biology curriculum in secondary schools in Israel,

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enabling to coherently integrate CE, SSI, and RRI together with the IBSE and align these aspects between the curriculum and the matriculation examination.

***Introduction***

A theoretical framework for Socio-Scientific Inquiry Based Learning (SSIBL), developed in the course of the PARRISE (Promoting Attainment of Responsible Research and Innovation in Science Education) project, was used as a basis for the analysis reported in this study. The SSIBL framework is based on four pillars which are integral to the SSIBL pedagogy: i) Inquiry-based Science Education (IBSE); ii) Citizenship Education (CE); iii) Socio-scientific Issues (SSI); and iv) Responsible Research and Innovation (RRI, Levinson & The-PARRISE-Consortium, 2014). The first one, namely IBSE, is well known and widely spread in various curricular documents around the world (e.g., European Commission, 2007; National Research Council [NRC], 2000, 2012; Tamir, 2004), while the other three pillars are rather rare in such documents, and especially CE and RRI.

In Israel, the educational system is centralized thereby the curriculum is dictated by the ministry of education. At the end of the $9^{th}$ or $10^{th}$ grade, students choose to major in at least one scientific or non-scientific topic, which is evaluated in a national matriculation examination. The curriculum for biology majors studies (300 hrs of teaching; Israeli Ministry of Education, 2011) includes three compulsory core topics. Students are also required to learn two elective topics which are chosen out of eight different topics. The biology matriculation examination is aimed at assessing knowledge related to the core and elective topics, comprehension of content and high-order thinking skills or inquiry skills. Between one-third and one-half of the national matriculation examination is aimed at assessing students' inquiry skills (Zohar, Schwartzer, & Tamir, 1998). In this respect, students are also assessed for inquiry laboratory skills and on an ecology-based inquiry project (Israeli Ministry of Education, 2011; Zion, Slezak, et al., 2004).

The general introduction to the curriculum states that the program emphasizes the ethical aspects of all the topics. Dealing with the ethical aspects, in the various contexts of the curriculum, is expected to enable the future citizens to be knowledgeable about issues which are on the current agenda at both the personal and the societal levels. The biology majors curriculum in Israel is well known for the innovative means used for learning through inquiry and for evaluating students'

knowledge about inquiry in the matriculation examination (Zion, Shapira, et al., 2004). However, the ethical aspects of the biology majors' curriculum in Israel and their interrelations with learning through inquiry were not examined yet.

***Objectives***

We wish to understand the extent to which the four pillars of SSIBL are addressed in the intended curriculum for $10^{th}$-$12^{th}$ grade biology majors in Israel (16-18 years old), and to assess the constraints and challenges in realizing and implementing them in the classroom.

***Methods***

The Israeli curriculum for biology majors (Israeli Ministry of Education, 2011) is composed of four main parts: i) an overarching view; ii) core topics; iii) elective topics; and iv) hands on inquiry and learning in the laboratory. The entire text of the curriculum was analyzed top-down using the four pillars of SSIBL: IBSE, CE, SSI, and RRI, and their relative emphases in the curriculum were evaluated.

***Results***

Analysis of the four parts of the biology majors' curriculum in Israel revealed that all the four SSIBLE pillars are represented in the curriculum with varying degrees of emphasis (Table 1). In the overarching view document, all the four pillars are mentioned. Interestingly, two sections in the overarching view document lack any reference to either one of the examined pillars, namely 'Core ideas and fundamental concepts' and 'Assessment' (Table 1). Thus, it seems that despite the explicit declaration that all four pillars of SSIBL are at the basis of the biology curriculum, these pillars are not represented in the actual content of the curriculum (core ideas and fundamental concepts), nor in its assessment.

The discrepancy between the general statements that appear in the overarching document with regards to the four SSIBLE pillars and the content of the curriculum was identified in the other two documents as well. In the document describing the core topics, IBSE was found to be mentioned only once in the introduction to Ecology, while the other three pillars (CE, SSI, and RRI) minimally appear in all the three core topics (Table 1). Similarly, in the document describing the elective units, none of the units is linked to IBSE, only two units are linked to CE, while SSI and RRI are represented with varying degrees of emphasis in the various units. In the

majority of the elective units, SSI and RRI are only minimally mentioned, while in the topic 'Human body systems' none of the pillars of SSIBL is mentioned (Table 1). Specific examples of the classification of the information provided in the curriculum and the four SSIBL pillars appear in Table 2. Taken together, in the theoretical part of the curriculum, despite the declarations that appear in the overarching view document, IBSE is only minimally represented in all the content topics (core and elective) that are studied in class. In contrast, in the 'Hands-on inquiry and learning in the laboratory' document IBSE is mentioned extensively as expected. Yet, the other pillars are almost completely not addressed (Table 1).

***Discussion***

The findings of this study point out that all the four pillars of SSIBL are addressed in the biology curriculum in Israel, but these pillars are not integrated in a coherent manner as the SSIBL framework suggests. Apparently, the application of three of these pillars (namely CE, SSI, and RRI) in teaching in the field is even at a lower level (data not shown). This is probably due to the fact that these three pillars are essentially non-existing in the national matriculation examinations. With the exception of IBSE, the other three pillars of SSIBL are almost completely omitted from the implemented biology curriculum as many teachers declare they are suffering from shortness of time and teaching priorities tending towards the matriculation examinations (data not shown).

These findings call for a reform in the biology curriculum in secondary schools in Israel, enabling to integrate the four SSIBLE pillars. The reform should strive for an alignment between the curriculum and the matriculation examination, the establishment of teachers' professional development programs to acquire the relevant knowledge and skills in implementing these pillars in an integrated manner.

**Table 1: Distribution of the four key pillars of the SSIBL framework within the intended high-school biology curriculum in Israel**

| | | | Key aspects of SSIBL framework | | | |
|---|---|---|---|---|---|---|
| | | | Inquiry-based science education (ISBE) | Citizenship education (CE) | Socio-scientific issue (SSI) | Responsible research & innovation (RRI) |
| **Overarching view** | Conceptual approach | | ☑☑ | ☑☑☑ | ☑☑ | ☑☑ |
| | Core ideas and fundamental concepts | | | | | |
| | Ethical/moral aspects in biology education | | | ☑ | ☑ | |
| | Development of thinking and learning strategies | | ☑ | | ☑☑ | ☑ |
| | Goals | | ☑☑☑ | ☑☑ | ☑☑ | ☑☑ |
| | Assessment and feedback | | | | | |
| **Core topics** | Introduction to the human biology (with an emphasis on Homeostasis, [45h] | Introduction | | | ☑ | ☑ |
| | | Overview | | ☑ | ☑ | ☑ |
| | | Core Ideas (n=9) | | | **1** | |
| | The living cell – structure and function [45h] | Introduction | | | | |
| | | Overview | | ☑ | ☑ | ☑ |
| | | Core Ideas (n=7) | | | **1** | **1** |
| | Ecology [45h] | Introduction | ☑ | ☑ | ☑☑ | ☑☑ |
| | | Overview | | ☑ | ☑ | ☑ |
| | | Core Ideas (n=7) | | **2** | **3** | **3** |
| **Elective topics** | Microorganisms I [30h] | Core Ideas (n=16) | | | **2** | **6** |
| | Microorganisms II [32h] | Core Ideas (n=14) | | **1** | **2** | **5** |
| | Reproduction [32h] | Core Ideas (n=12) | | **1** | **3** | **3** |
| | Heredity [48h] | Core Ideas (n=15) | | | **1** | **2** |
| | Reproduction and development in plants (from seed to seed) [32h] | Core Ideas (n=10) | | | **1** | **2** |
| | Nutrition of plants and animals [44h] | Core Ideas (n=10) | | | **1** | **1** |
| | Evolution [26h] | Core Ideas (n=10) | | | **1** | **1** |
| | Animal behavior [30h] | Core Ideas (n=6) | | | | **1** |
| | Human body systems (transport, secretion, respiratory, defense) [50h] | Core Ideas (n=11) | | | | |
| Hands-on inquiry and learning in the laboratory (120h) | | | ☑☑☑ | ☑ | | |

in brackets: [number of hours (h)] and (n=number of core ideas)

Frequency of references to a given SSIBL pillar — ☑ minimal ☑☑ medium ☑☑☑ extensive

Number of Core ideas in which a certain aspects of a SSIBL pillar are expressed — 1 2 3 4 5 6

**Table 2: Examples from the intended high-school biology curriculum which refer to the four key pillars of the SSIBL framework**

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="4">Key aspects of SSIBL framework</td></tr>
<tr><td>Inquiry-based science education (ISBE)</td><td>Citizenship education (CE)</td><td>Socio-scientific issue (SSI)</td><td>Responsible research & innovation (RRI)</td></tr>
<tr><td rowspan="2">Overarching view</td><td rowspan="2">Conceptual approach</td><td colspan="3">Science as a process: science does not accept any explanation for granted, but strives to ask questions and examines any question using controlled experiments. It is an ongoing research process, which is built on knowledge that grows and continues to change all the time. This process encourages (among other things) discussions, provides different interpretations and explanations in light of previous studies.</td><td></td></tr>
<tr><td></td><td colspan="3">Relationships between science technology and society: There are connections between science, technology and society, which are reflected in part in technological developments and in agricultural, environmental, social and ethical contexts relating to everyday life.</td></tr>
<tr><td rowspan="5">Core topic: Ecology</td><td rowspan="3">Introduction</td><td rowspan="3">It is recommended to teach the subject while tracking one of the nearby habitats over time. This will allow students to be familiar with the habitat including its diverse components, the relationships between the organisms in / and the habitat.</td><td colspan="3">Relevant issues regarding hunman's involvement with the environment on a global, regional and local levels. Agriculture as an example.</td></tr>
<tr><td colspan="3">Promoting awareness to dilemmas which relate to hunman's responsibility for his environment, and issues of environmental development vs. conservation.</td></tr>
<tr><td>Allowing natural resources to replenish, for the benefit of future generations.</td><td>Sustainability (of development and agriculture).</td><td>Survival of the human race through controlled intervention in nature.</td></tr>
<tr><td colspan="3">Student will closely examine aspects of the human impact on the habitat (either natural or artificial).</td><td></td></tr>
<tr><td>Overview</td><td></td><td colspan="3">Understanding the principles and concepts of ecology is fundamental to understanding human's effect on the environment and is a starting point for every action for environmental conservation.</td></tr>
<tr><td>Core ideas</td><td></td><td colspan="3">Human's Involvement in nature raises issues as well as social and ethical dilemmas:<br>• Responsibility of people as individuals and as a group to the environment: the importance of protecting the environment and its resources, the importance of maintaining biodiversity.<br>• Issues related to environmental conservation: establishment of natural reserves, developmental activities while reducing the damage to nature (e.g., highways, power plants on the beaches).<br>• Dilemma of conservation vs. Development<br>• Extinction of species, the introduction of species, Bio-geografic barriers, sustainable development, sustainability</td></tr>
</table>

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