Advancing group epistemic practices in the resolution of interdisciplinary societal dilemmas

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Abstract

The present paper inquires whether a meticulous program designed to resolve Interdisciplinary Societal Dilemmas through dialogic argumentation advances epistemic practices. To delineate how epistemic practices are manifested in classroom discussions, we adopted the Actor-Network Theory (ANT), which explores the interactions and agencies of human and non-human actors. ANT analyses uncover the power these actors exert on each other and help recognize the networks that these actors create or dissolve. They also delineate how epistemic practices emerge and are shaped in these networks. We identified four epistemic practices in the discussions: (1) taking a reasoned position, (2) integrating knowledge from different disciplines, (3) weighing pros and cons before taking a complex position, and (4) role-playing in a democratic game. We show that the type of discourse developed in the program was mostly dialogic argumentation. In addition, we demonstrate how teachers often inhibit these advancements. Indeed, in the case of integrating knowledge from different disciplines, teachers' role is central, but the emerged actors' network is often non-dialogic. Moreover, we show how non-human actors shape the interactions in networks as well as the formation of knowledge and agency. We conclude that: (a) the design of activities for resolving interdisciplinary societal dilemmas provides many opportunities for advancing epistemic practices, (b) these practices are mostly advanced through dialogic argumentation, but (c) more efforts should be invested in affording interdisciplinary argumentation.

Keywords: dialogic pedagogy, epistemology, actor-network theory, interdisciplinarity

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Introduction

Nowadays, interdisciplinarity has good publicity in the educational system. In higher education, interdisciplinarity is a natural way to handle new theoretical and practical fields such as ecology, nanotechnology, or biochemistry. These fields have become disciplines of their own with their distinct instruments and methods. However, for the most part, interdisciplinarity has gained popularity not because it opens new fields but because it has a motivational role, especially in secondary education. Indeed, the rise of knowledge domains as disciplines was traditionally aimed at training learners to master methods and strategies used in schoolish activities, not "real problems."(Sadler, 2009). Socio Scientific Issues (SSIs) – represent topics the scope of which is societal. Thus, students' engagement and the application of scientific ideas are frequently discussed in schools. As Sadler (2009) argues, SSIs motivate students to learn science: they feel the relevance of science to their lives as citizens, and this relevance boosts their engagement in the resolution of SSIs. Schwarz and colleagues (Schwarz et al., submitted) have attributed the flourishing of interdisciplinary programs (and not only programs in science education based on the extensive capitalization on SSIs) to a more comprehensive reason related to the traditional compartmentalization in the teaching of disciplines. They suggest that the flourishing of interdisciplinary activities conveys a post-modernist stance, in which reason cannot conquer the world and cannot solve all problems. However, despite this immense popularity, research focusing on deploying interdisciplinary processes induced by these programs in classrooms is scarce. Schwarz and colleagues (Schwarz et al. submitted) have argued that *dialogic argumentation* may enable the deployment of interdisciplinary processes but that this deployment depends on a meticulous design. Although there is substantial literature on principles of design tasks for disciplinary engagement (Engle & Conant, 2002) or dialogic argumentation (e.g., Andriessen & Schwarz, 2009), *interdisciplinary dialogic argumentation* is a relatively new field of research. Koichu and his colleagues (2022) proposed design principles for *interdisciplinary dialogic argumentation*. These are content-related, pedagogy-related, and organization related. The design principles Koichu and his colleagues identified are essential, but they do not tell about the nature of the discourse induced by this design among students.

Tsemach & Schwarz (2022) used ANT to assess whether the discourse deployed in a program in which tasks were designed to afford interdisciplinary dialogic argumentation was indeed dialogic. The ANT concepts and methodology is described in detail further on. It explores when and how human and non-human actors assemble and interconnect into dialogic networks and when these networks evolve and dissolve. In this study, we used ANT to examine epistemic practices and their advancements in the context

of interdisciplinary programs in schools. The program we focus on here is a case-study for this matter. The program was designed to resolve Interdisciplinary Societal Dilemmas through interdisciplinary dialogic argumentation in four junior-high schools in a mid-size town in the central part of Israel. We check the effectiveness of the design by addressing and analyzing the actors who shape the dialogic and non-dialogic networks. In addition, we trace how epistemic practices emerge and evolve in classroom activities and discussions.

It is accepted that epistemology concerns not only the nature of knowledge but also its limits and how it is constructed, processed, and evaluated (Greene et al., 2016). We follow *epistemology as a social practice* approach to the study of epistemology in educational contexts that explores how knowledge is produced, evaluated, and justified through interactions among individuals (Kelly, 2016).

The next sections provide a general background on our research by (a) providing a brief review of how research about epistemology is approached in the Learning Sciences and (b) sketching the fundamentals of the Actor-Network Theory.

Research on epistemology through the observation of social epistemic practices

Three general research directions have been adopted to study epistemology in education, *personal epistemology, disciplinary epistemology*, and *social epistemic practices*. *Personal* epistemology is a prominent research perspective that often follows fixed models and tools to assess students' epistemological stances and beliefs (Greene et al., 2016a; Kelly, 2016). This perspective has revealed valuable insights regarding the connection between epistemic stances and the learning outcomes of individuals. Research on *personal* epistemology traces the modification of general models to contextual models that perceive epistemic cognition as sensitive to the context and subject domains (Barzilai & Weinstock, 2015; Bråten & Strømsø, 2009). Other studies examine epistemology as stances that guide learning in situ. Such studies inspect how epistemology is situated in cases where students as individuals have to assess, evaluate and create knowledge (Barzilai & Zohar, 2012; Mason et al., 2011).

A second perspective on the study of epistemology is *disciplinary*. Kelly defines this perspective as "specific ways members of the community propose, justify, evaluate and legitimize knowledge claims within a disciplinary framework" (Kelly, 2008, p. 99). This perspective focuses on epistemic disciplinary practices. For example, Cunningham and Kelly (2017) examined how elementary school teachers framed engineering practices in elementary school classrooms. The teacher invited her students to participate in aerospace engineering activities and instructed them to design a parachute for space landing, considering how its characteristics affect its drop speed. In reflection on this data, Kelly (2016) delineated how epistemic practices, such as observation, data analysis, and redesigning, are embodied in teacher and student interactions. Knowledge is produced and considered intersubjectively between the participants and relevant texts. For example, educational settings and activities facilitate students' conception of justifying scientific conclusions on observations and data analysis. In another study, Kelly et al. (2000) examined how teachers in oceanography universities frame the epistemological positions of the disciplines to the students. They delineated how the course mentors and the students jointly defined, communicated, and set epistemic positions of oceanography. Hamza and Wickman (2008) and Wickman (2002) explored how students' engagement with knowledge in science learning is shaped through social interaction, the context, and students' previous knowledge and experience. While the personal perspective focuses on the epistemic beliefs of individuals, mostly expressed in interviews or questionnaires, the disciplinary perspective focuses on utterances during scientific practice. Although this perspective considers the context, the utterances are generally extracted as isolated elements.

Finally, a third perspective is the study of epistemology as a social practice (Greene et al., 2016b; Kelly, 2016). This perspective explores how epistemologies are enacted in social settings (Kelly, 2016). Following socio-cultural approaches to learning (Lave & Wenger, 1991; Vygotsky, 1978), this perspective conceptualizes epistemology as a social practice, as students and teachers define what counts as knowledge and create, assess, and evaluate knowledge claims. We extend the scope of the study of epistemology as a social practice to its study as a socio-*cultural* practice. We perceive knowledge as a process and an outcome that emerges through the interaction among individuals as well as with different artifacts in specific contexts rather than the individual achievement of mental possession. Knowledge is created, distributed, and considered through discourse processes among people and with various texts.

In this paper, we study epistemology as a socio-cultural practice and observe the emergence and development of epistemic practices in classrooms. For this study, we use the Actor-Network Theory.

Actor-Network Theory

ANT explores how actors shape and are shaped by the interactions and how they exert power and agency on each other (Latour, 1984). The theory was developed as a critique of traditional sociological research on the grounds that it examined the "social reality" by focusing on the actions and intentions of human actors (Latour, 2005). According to the methodological concept of *symmetry*, objects, materials, and technology are not just objects subjugated by humans. Non-human actors shape interactions, exert force, and clout humans' epistemology, learning, and knowledge manifestation (Fenwick & Edwards, 2010; Latour et al., 1979).

ANT explores the associations and interactions of the socio-material. It describes how these actors (known as *actants*) interact, shape, and are shaped by each other and thereby assemble into networks (Fenwick & Edwards, 2010). In their ethnography of *science-in-the- making* in a laboratory, Latour and Wooglar (1979) revealed how scientists' epistemology is constructed through relations with non-human actors such as machines, routines, and scientific assertions.

ANT has been used in educational studies. It allows scholars to explain learning processes based on interactions between teachers, students, and non-human actors, such as teaching aids and educational technologies. Law (1992) demonstrates how overhead projectors are used by teachers and students to present and discuss ideas. As non-human actors, these pedagogical aids have an agency that affects the learning process and how students develop ideas. Thus, this technology has an agency in shaping interaction, learning, and epistemology (see McGregor, 2004, for similar use of ANT in technology-rich contexts).

In educational studies in ANT, the general idea of *translation* of the ANT theory is central to understanding how learning processes, knowledge building, and epistemic assumptions are created. The concept points to the possibility of transformation and change of form that produce equivalence, from actant to actant, so that actants stand in place of something else. In this sense, technologies and pedagogical aids are used to translate ideas, thoughts, and knowledge. Knowledge, roles, and agency are not pre-given attributions; they are effects of interactions between different actors in specific contexts. Similarly, knowledge and epistemology are not conceived as mental resources held by individuals but rather as the effects of a specific network that emerged through interaction between different actors (Fenwick & Edwards, 2010). McGregor (2004) showed the process of a science teacher becoming a knowing location through the interaction of materials (Bunsen burners, flasks, etc.), routines and timetables, texts (science books), people, and her former experience and education. Similarly to Latour and Wooglar's (1979) interpretation of laboratory life, she describes how laboratory artifacts, instructional practices, and the teacher's behaviors are assembled into a network and create knowledge and agency.

Sometimes configurations shaped in a particular network can solidify and be fixed (immutable) while being mobile and traveling to multiple other networks that continue to shape their interaction (Fenwick & Edwards, 2010). Latour (1987) calls these configurations *immutable mobile*. After their creation, they move between time and space, extending their power. Sometimes, when moving to different networks, the circumstances of their creation remain unknown or are ignored (Fenwick & Edwards, 2010). Indeed, Latour and Woolgar (1979) described how laboratory inscription devices transform pieces of matter into graphs. The scientist's epistemic assumption regards these devices and graphs as having direct relationships with the substance examined. Once produced, the graphs can be borrowed, cited, and compared. Thus, they start to shape the interaction in multiple other networks. Likewise, the national curriculum acts as immutable mobile, as it is produced in specific circumstances, is consolidated, and then travels and shapes learning and epistemology in different classrooms, transferring knowledge and shaping interactions and procedures (McGregor, 2004).

A new research direction: Using ANT to observe epistemic practices in classroom discourse

In the present research, we adopt a socio-cultural approach to the study of epistemology. Our research question concerns the deployment of epistemic practices in classroom talk induced by a program aimed at facilitating interdisciplinary dialogic argumentation in schools. We ask which epistemic practices are advanced in such a program and aim to recognize how these practices are deployed in time.

Although raising hypotheses for such a research question is difficult, we were aware that theorists link *dialogic* discourse to epistemology. For example, Wegerif and colleagues (Wegerif et al. 2019) provide three definitions of dialogues: everyday, ontological, and epistemological. The third definition is based on two assumptions about meaning and knowledge creation. One is *dynamism* - knowledge is an effect of continuous and everlasting interaction between people and the world. Knowing the external world manifests only within a dialogue of continuous and lasting process of questioning and answering. Thus, the perception of what counts as knowledge is dynamic. The second is *contextuality* - the meaning of every utterance is understood in a context by understanding its relations to previous (and future) utterances. We were aware, though, that such considerations were theoretical.

Other researchers have linked dialogic discourse and scientific argumentation to epistemology from a pedagogical point of view and have pointed out that epistemology differentiates dialogic pedagogies from traditional ones (Alexander, 2020; Driver et al., 2000; Nystrand et al., 2003; Sandoval and Millwood, 2007). For them, dialogic and argumentative discourse aim at facilitating active engagement of students with the construction of knowledge and involve genuine inquiry, compared to traditional approaches focusing on the teachers and textbooks as the source of knowledge.

Some studies explore classroom discourse and concentrate on epistemological aspects of learning (Pollak, 2017). Two linguistic-ethnographic studies about epistemic climate present a complex picture that emphasizes epistemology's sensitivity to educational contexts and practices. Lefstein and Snell (2011) analyze and expose how epistemic dimensions are reflected in 10-11-year-old students' English classroom discourse. From the discourse emerged an epistemology that conceived of knowledge as tentative rather than fixed, seeing the students' active roles in constructing knowledge with peers instead of the teachers being the primary source of knowledge and knowledge as built through the interaction of different perspectives. Pollak's (2017) findings ratify and contradict some of these findings. He analyzed the enacted epistemology in 4th-6th grade language art lessons and included a quantitative description of epistemic practices. Among the findings, Pollak depicted how students are the source of knowledge when their beliefs are shared in classroom discussions. However, these beliefs are transformed into knowledge through the

teachers' validation; only then is the knowledge treated like a fact. Epistemic practices are implicit and ambiguous, and lack shared language between students and teachers to reflect and evaluate knowledge. Pollak also relates to the processes of knowledge structure. He concludes that knowledge remains isolated and disconnected from larger knowledge structures and is affected by the specific activity's traits and time constraints.

Another study, presented by Tan and Tang (2019), explored the role of dialogue in epistemic practices in science classrooms, which resembles Kelly's studies (Cunningham & Kelly, 2017; Kelly, 2016). They present four epistemic practices: questioning, inquiry, argumentation, and legitimizing conceptual knowledge, in which students can be engaged and, in this manner, be encultured to science.

From the research review on the links between classroom discourse and epistemology, we saw that theorists of dialogic education and classroom discourse have articulated differences between dialogic and non-dialogic pedagogies. Our research question explores a temporal dimension of epistemic practices induced by a program aimed at facilitating interdisciplinary dialogic argumentation in schools. We ask about the epistemic practices that emerged in the program. Since, as will be described in the next section, the program was designed to afford interdisciplinary dialogic argumentation, it was reasonable to conjecture that various epistemic practices would emerge in the program: an invitation to interdisciplinarity brings to the surface disciplinary knowledge, its limits, and issues on sources of knowledge.

The educational context

A program aimed at promoting interdisciplinary dialogic argumentation in school was initiated in four junior-high schools in a mid-size town in the central part of Israel under the auspices of the inter-university Dialogos Center. We organized a series of special one-day-long events, "focus days," in which students from the four schools convene in a municipal education center. There, they would participate in activities prepared in collaboration with the Dialogos team, but conducted by the regular teachers at the participating schools.

Overall, during two academic years (2019-2021), about 150 students from the four junior-high schools participated in eight "focus days". Each focus day focused on a different Interdisciplinary Societal Dilemma (ISD) (see Table 1). Each focus day began with an introductory talk given by an expert knowledgeable about the chosen ISD. Then two 90-minute disciplinary sessions took place, in mathematics, science, or philosophy. Each student participated in two sessions in different disciplines. Following the two disciplinary sessions, a 90-minute interdisciplinary session took place, in which the students discussed the ISD of the day while capitalizing on what they had learned in the disciplinary sessions. At the end of each focus day, a joint product (e.g., a presentation, a short movie, a written story) was produced; deliberations were conducted in all disciplines around texts that invited inquiry and dialogic argumentation. During most focus days, the students and teachers of the four schools convened face-to-face in the municipal education center. Due to the Covid-19 pandemic lockdowns, two focus days (Day 5 and Day 6) took place in an online synchronous learning environment.

Table 1. The ISDs for the eight focus day

	Interdisciplinary Societal Dilemma (ISD)
Day 1	**Biometric passports**: The Supreme Court will soon have to decide whether the citizens' DNA sequence information be added to their biometric passports. Help them reach a decision.
Day 2	**Sustainable development**: Your municipality will decide how to divide the city's open areas among three developmental projects: buildings, nature reserves, and communal

	areas. Help the municipality choose the most appropriate and democratic way to consider the inhabitants' preferences.
Day 3	**The vaccines dilemma**: Should the state mandate parents to vaccinate their children?
Day 4	**Genetic engineering in humans**: Should the state allow interested parents to genetically engineer their future babies?
Day 5	**Fake news**: As an editorial board member of your school bulletin, you should decide which four out six submitted papers will be published in the bulletin using the following criteria: precision and reliability, preservation of freedom of speech, respect for the authors, and the readership.
Day 6	**The educational system dilemma during the Covid-19 crisis**: Should schools in your municipality be closed or open during lockdowns? If open, in what format?
Day 7	**Ethics in competitive sport**: Should competitions participants be permitted to enhance their performance using self-blood transfusion or other artificial means?
Day 8	**Fair distribution of resources**: In the north-east part of our country, a kibbutz took over natural spring water near its fenced territory and built an open tunnel that runs beside its inhabitants' houses. People from the nearby town, and many other activists throughout Israel, require free access to the tunnel for leisure and sports purposes. This implies free access to the kibbutz territory, which the inhabitants object. Suggest an arrangement that may resolve the dispute.

Methodology

Our data included more than twenty recordings of interdisciplinary lessons, both video, and audio. These lessons focused on group work, and we recorded 3-4 groups each time. After sorting the recordings, we decided to leave some of them out of the sample due to bad-quality audio. We analyzed more than 50 recordings of group work. The length of recordings was between 12-30 minutes long. All recordings were transcribed. We analyzed the transcripts alongside watching the videos, if available.

Based on ANT methodology, our analysis focused on: (a) Identifying which human and non-human actors are involved in the interaction; (b) Describing the associations created between the actors and how these assemble together; (c) Delineating the power and agency exerted during the interactions. Following our first efforts (Tsemach & Schwarz, 2022), we observed how dialogues were created and dissolved in networks.

The first and third authors analyzed all the data separately. Then, they met and discussed their analysis and insights. The data analysis included three rounds. In the first two rounds, we tried to identify patterns of interactions and epistemic practices that repeated in different lessons and groups. Then we named and explained these patterns and practices. In the third session, we analyzed all the data again to refine our analyses and recheck which patterns were prominent and recurred in different lessons and group work. We chose four vignettes from our data that exemplify common epistemic practices and enable us to demonstrate the potential of ANT analysis to reveal epistemic practices in classroom dialogs. All students, students' parents, and teachers give their consent to participate in the study. All names that will be presented in the finding section are pseudonyms.

Findings

The following protocols are taken from two discussions on two different focus days. The discussions took place during the last part of the focus days – in which we designed an activity to afford interdisciplinary dialogic argumentation. As will be shown, four epistemic practices were enacted:
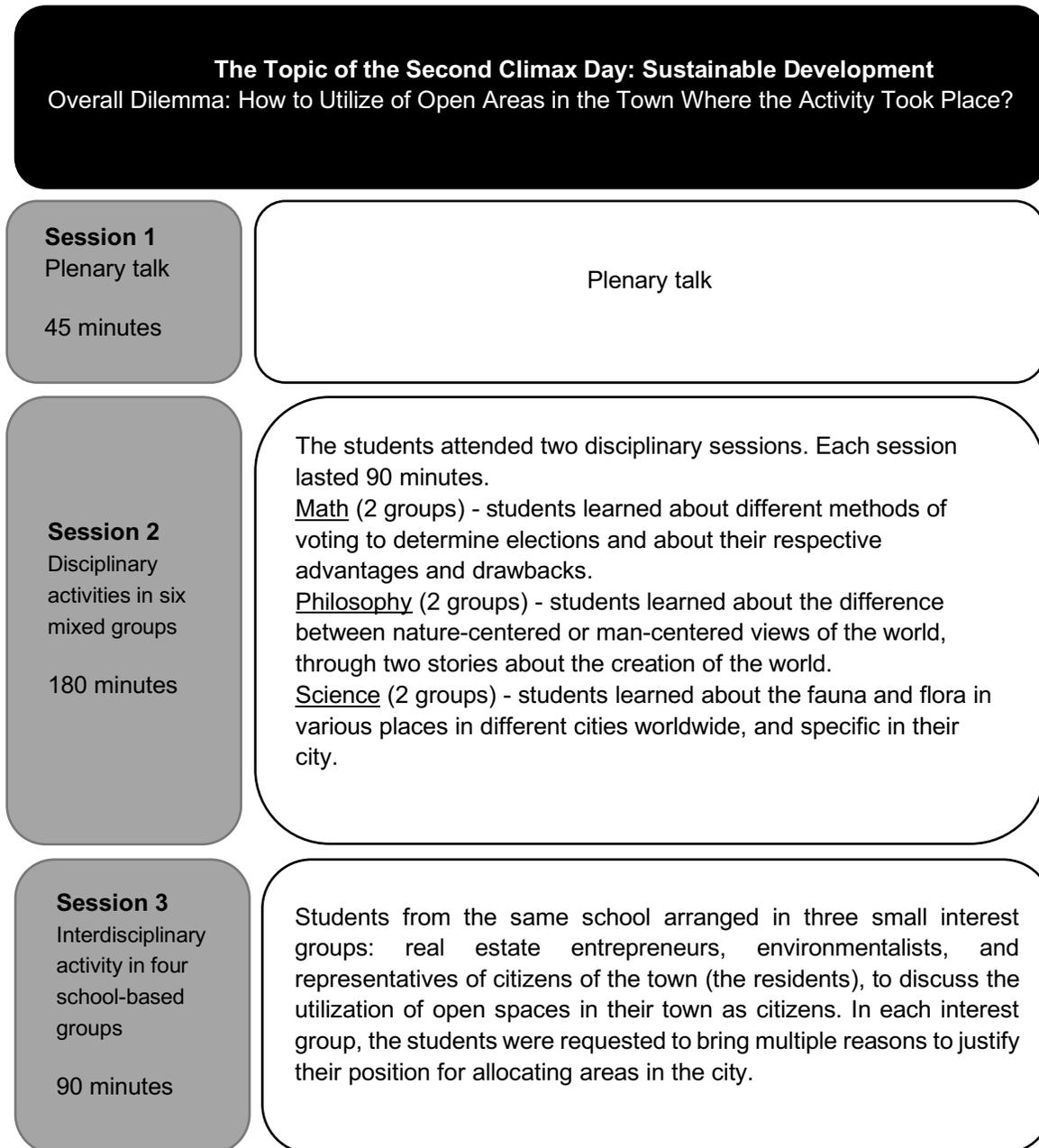
1. Taking a reasoned position
2. Integrating knowledge from different disciplines
3. Weighing pros and cons before expressing a complex argument
4. Playing a role in a democratic game

We will consider the role of the design and ensuing instructions or artifacts as non-human actors and of the teachers as catalyzers or inhibitors in advancing these epistemic practices among students. The ANT methodology interweaves macro- and micro-processes: interactions cannot be understood without being contextualized within a particular network in which they take place. This specificity of ANT entailed the impossibility to describe the emergence and evolution of each epistemic practice separately. Subsequently, in the following sub-sections, we will describe the conjunction of epistemic practices in relatively long excerpts.

The first story of two epistemic practices in classroom talk – Taking a reasoned position and integrating knowledge from different disciplines

We present excerpts from a discussion during the second focus day on the exploitation of open spaces in a city. The overall topic of the second focus day was the utilization of open areas in the town where the activity took place. The town's deputy mayor talked about the municipal council's policy in this town. Students were then arranged in mixed groups of around 20 students from the four schools. Each group focused on a disciplinary activity – in Mathematics, Science, or Humanities that lasted 90 minutes and that was related to the general issue at stake. In Mathematics, students presented the preferences of citizens in their town about the utilization of open areas (living area, public park, reserve) and learned about different methods of voting (majority, absolute majority, Borda count method, Pairwise Comparisons Method). They also learned about their respective advantages and drawbacks and were asked about the best voting method for using open areas in cities. In Philosophy, the teacher triggered a discussion about the difference between culture and nature and then arranged dyads to report on things from nature vs. artifacts that they like the most. Then, the teacher invited students to learn two stories about the creation of the world – one man-centered mythological tale from Ancient Egypt and one nature-centered Central African tale and asked students how nature and cultural artifacts are valorized in the two tales. In the Science session, students were first invited to observe numbers and varieties of birds and plants side the building where the focus day took place. The teacher then provided data about the fauna and flora in various places in different cities worldwide. He then created small groups and invited them to discuss the relations between the variety of birds in different places (living areas, public parks, and reserves), the average income of the inhabitants, and the population density. In a second session, new groups of around 20 students were set, so all students attended a session in a new discipline. Figure 1 displays the stages of the focus day.

Figure 1: Climax Day's Structure

The Topic of the Second Climax Day: Sustainable Development
Overall Dilemma: How to Utilize of Open Areas in the Town Where the Activity Took Place?

Session 1 Plenary talk 45 minutes	Plenary talk
Session 2 Disciplinary activities in six mixed groups 180 minutes	The students attended two disciplinary sessions. Each session lasted 90 minutes. Math (2 groups) - students learned about different methods of voting to determine elections and about their respective advantages and drawbacks. Philosophy (2 groups) - students learned about the difference between nature-centered or man-centered views of the world, through two stories about the creation of the world. Science (2 groups) - students learned about the fauna and flora in various places in different cities worldwide, and specific in their city.
Session 3 Interdisciplinary activity in four school-based groups 90 minutes	Students from the same school arranged in three small interest groups: real estate entrepreneurs, environmentalists, and representatives of citizens of the town (the residents), to discuss the utilization of open spaces in their town as citizens. In each interest group, the students were requested to bring multiple reasons to justify their position for allocating areas in the city.

The students were finally re-arranged in groups of 20 from the same school to discuss the utilization of open spaces in their town as citizens. The teacher split the group into three small interest groups: real estate entrepreneurs, environmentalists, and representatives of citizens of the town (the residents). In each interest group, the students were requested to bring multiple reasons to justify their position for splitting the land.

The protocol below describes the activities of a "residents" group. Several humans and non-humans were actors. A group of five female students worked alone. Several instructions served as actants

– non-human actors: (a) to propose a suggestion for dividing the land (the percentage allocated to each goal) using a diagram pie, (b) to present supporting reasons for their position, and (c) to build their arguments based on information from previous units (philosophy, math, and science). We will show how these actors interacted – created a network of interactions. The network whose deployment will be described follows the deployment of other networks: the instructions were created in a different network by researchers in math, science, and philosophy education (Koichu et al., 2022). As will be shown, the instructions created in that network shape interactions in the network we will describe.

Finally, each interest group was told that a discussion with representatives of different interest groups to reach an agreement about allocating the lands. In Table 2, we show the beginning of the discussion among the group members.

Table 2. Excerpt 1 showcases the first story of two epistemic practices in classroom talk.

Line	Speaker	Talk
1	Shaked	What do you say if I take a picture of the board and we can look at it right in front of our eyes?
2	Noa	Yes
3	Shani	No
4	Shahar	No, but let's copy it from the board
5	Shani	But the residents don't care about that
6	Shahar	I'm thinking gardens and parks, because we need occupations and such, open spaces. The uniqueness, at least in my opinion, of Nes Ziona is that it is quiet here. If say you live in Tel Aviv, you will have noise
7	Shani	Right
8	Ori	That's exactly why open areas
9	Shani	Come on, we are the residents
10	Shahar	First open areas, then parks
11	Shani	But we are the residents, so shouldn't it be the gardens and parks?
12	Shahar	Yes, because you think that...
13	Shani	Because we are the green city
14	Shahar	Think about it now. Let's say your parents, not let's say Noa's parents. What would they prefer - to have open areas or activities for children?
15	Noa	For children
16	Shahar	Well, exactly, so gardens and parks

Shaked begins the discussion by suggesting copying from the board what they learned from the session in mathematics – ways to choose the best solution when there is no unanimity (4). She suggests incorporating a non-human actor, a data set, to guide their interaction. However, they agree that this artifact is irrelevant to the residents and, therefore, is not incorporated into the network (5). Then, they show hesitation about what is the interest of residents (6-16). They agree that they must keep their city green but hesitate between favoring open spaces and parks or playgrounds. They construct their arguments about their common interests collaboratively. The interacting actors constitute a dialogic network in which no actor

is subjugated by others. They participate in dialogic argumentation and participate in the epistemic practice of expressing a reasoned position (14-16), that can be paraphrased as "as residents, we prefer gardens and parks since we care for our children and want them to have space for activities that fit their age." In Table 3, we see that this dialogic network quickly dissolves as the teacher joins it and gives a definite direction to the discussion.

Table 3. Excerpt 2 showcasing the first story of two epistemic practices in classroom talk.

Line	Speaker	Talk
17	Teacher	Hi girls
18	In chorus	Hey
19	Teacher	So actually you... your support of the city residents is public gardens and parks, when we actually say is it nature, or man, culture? Is it something natural or something man-made? However, if it is man-made - a factory, a building? Or are we talking here about a structure of...
20	Shahar	About employment
21	Shani	No, but as far as we know, Nes Ziona...
22	Teacher	Would you talk about a park? Is a park something that is not natural?
23	Shahar	No
24	Teacher	Fundamentally?
25	Shani	No
26	Teacher	Where does the park originate ? A park with flowers and trees?
27	Shahar	Oh. Yes
28	Teacher	Is it unnatural? It is natural but…
29	Shani	It depends on which one, there are parks...
30	Teacher	That is its result. Its role in nature is that of an ornament, and oxygen and other things that... fine. But who put it there?
31	Shani	We
32	Noa	It is domesticated nature
33	Teacher	It is domesticated nature, or cultured, civilized nature
34	Shaked	Great idea
35	Shani	Some plant, the plants in the shape of, there are those who do it in the shape of, flower, or they do it in the shape of a certain person
36	Shaked	They are doing it in such a beautiful way
37	Shani	Yes

When the teacher joins the discussion, she asks, "your support of the city residents is public gardens and parks when we actually say is it nature or man, culture? Is it something natural or something man-made?" (19). This question reminds the students that they participated in a philosophy session in which they learned about the natural and man-made categories. The aim of the teacher is clear. She wants

the students to participate in another epistemic practice – to incorporate knowledge from various disciplines in their argument.

The teacher is the focal point of this network: she decides the topic of discussion and who will focus. Some of the students' answers show that they do not understand what the teacher wants from them (like Shahar's "about unemployment" in (20)). Interactions are mostly with the teacher, and turns are short. The students try to comply with the direction the teacher intends to give to the discussion, and Noa uses the term "domesticated nature", which had been used in the philosophy session. However, they do not adopt the teacher's direction (35-37). The teacher then tries again to capitalize on the ideas developed in the philosophy session (Table 4).

Table 4. Excerpt 3 showcasing the first story of two epistemic practices in classroom talk.

Line	Speaker	Talk
38	Teacher	Who here was in philosophy?
39	Shaked	Oh before? No, I was last time
40	Ori	No, today, today
41	Shahar	We, the four of us
42	Teacher	The four of you. So, you have read the texts about the creation of the world?
43	In chorus	Yes
44	Teacher	And in fact, the creation of the world in both texts are extremes: one extreme focuses on the nature and how man destroys it, and the other extreme focusses on man as the creator of social order only
45	Shani	He destroys and creates. No, but he destroys to produce something new
46	Ori	He creates things by destroying other things
47	Teacher	Did he create human culture?
48	Ori	Yes
49	Teacher	But he didn't preserve nature
50	Ori	Right
51	Shani	He destroys animals to eat them, let's say
52	Teacher	Is it necessary to destroy animals?
53	Shani	No
54	Teacher	So ok, this is actually the in-between border I'm talking about. There is a fine line that connects the two texts. Also, understand that man needs, for human culture, to build things, and to be industrialized and produce infrastructure for humans, and on the other hand, we need to preserve this natural resource called nature. You have to find the middle path. Ok? And the reasons for this... What is written for you on your information page? Supposedly yours is the most complex because it sits on both worlds
55	Noa	Because of this...
56	Teacher	Ok, so read me what is written before you

This excerpt shows an Initiate-Response-Evaluate (IRE) pattern of interactions between the teacher and the students: she asks the questions (38, 42, 52), gets shorts answers that show mere approval (43, 48, 50) or disapproval (53), and gives long explanations without being asked for (44, 54). Those explanations were produced in the philosophy session, and the teacher wants her students to use them. Most of the talk is produced by the teacher. Her reference in (42), (44), and (54) to two philosophical texts about the creation of the world is aimed at influencing the position of the residents. Her long and detailed argument in (54) does not leave room for the students. The protocol exhibits a network in which the teacher is at the center. The students are actors with little agency, as the teacher exerts her power on them. The students do not participate in the epistemic practice of expressing a reasoned argument. Their dialogic argumentation is replaced by a teacher-centered discussion, in which the teacher invites the students to participate in an epistemic practice – integrating knowledge from different disciplines. However, they do not participate in this practice. The instructions given to the teacher to relate to the previous lessons are an invisible actor which exerts their power on the teacher. The instructions are *immutable mobiles,* e.g., a configuration that was shaped in one network and then moved to another network exerts power and shapes the interaction. The circumstances of their creation have been forgotten, and the injunction "read me what is written before you" in (56) shows that the designers' aims in instructions have been forgotten. The next excerpt (Table 5) begins with the reading of instructions by Shaked.

Table 5. Excerpt 4 showcasing the first story of two epistemic practices in classroom talk.

Line	Speaker	Talk
57	Shaked	(Reads) The municipality of Ness-Ziona is very concerned about the issue of the remaining open spaces in the city. On the one hand, some residents cry out that the quality of the environment is deteriorating. The Iris reserves around the city are in danger! On the other hand, the city is young, its inhabitants multiply rapidly, and many new residential buildings are needed.
58	Teacher	This is the issue I presented to you. Ok, and your reasons, as residents of the city?
59	Shaked	I don't think so
60	Teacher	What does it say to you? Do you have reasons that you can find?
61	Shaked	We are interested in maximizing the quality of life of the city's residents. We are less interested in the new residents entering the city. In light of our interests, we must propose a pie diagram that will divide the remaining open areas in Ness-Ziona according to the percentages that you think should be allocated to each category (private homes and public buildings, nature reserves, and public areas such as gardens or parks).
62	Shani	In my opinion, I actually think that open spaces should be in the first place because the first thing is what makes Ness-Ziona unique
63	Teacher	Now, there is your personal opinion, and the opinion you represent in the interest group. What should be the priority in the interest group you represent?
64	Noa	Gardens and parks
65	Teacher	Also try to think about using an open area that has not been touched and is completely natural and wild and see why it serves the city. Perhaps it is better to create a domesticated nature, an urban nature, yes that can be

		enjoyed and that still serves the environment. This (reason) supports your (position)
66	Shaked	In my opinion, domesticated nature is not that much better than wild nature, but at different times, for example, when you want to walk around and that, domesticated nature is a better thing
67	Teacher	Why?
68	Shaked	Because there are animals that can be dangerous in normal and wild nature, but in domesticated nature there are not...
69	Teacher	Reason number one, you found excellent. This is reasoning. What more? What else is good about domesticated nature? What else is good in a cultured, civilized nature?
70	Ori	Me, I have an idea but I'm trying to formulate it
71	Noa	As parents, you know you are sending the children to the park
72	Shaked	And it is much safer
73	Shani	But in the parks, it's not...
74	Shaked	No one can come and eat them
75	Shani	Do parks mean kindergartens? (in Hebrew the word *gan* can be understood as park or kindergarten)
76	Teacher	Also, ornamental public gardens where you can also spend time there. We don't... You don't have public gardens here in Ness Ziona, I am not a Ness Ziona resident, where you can walk around, play and protect the environment?
77	Shahar	There is...
78	Ori	This is the park
79	Shaked	I don't *** (inaudible) as a safer place
80	Shani	At first, I thought of kindergartens as kindergartens, not parks
81	Teacher	No, not a kindergarten, I mean a garden of plants, *** (inaudible) beautiful, neat, organized, and the environment is also pleasant
82	Shani	Yes. Exactly
83	Shahar	People choose, say, this flower in this color, so they remember where to put *** (inaudible)
84	Teacher	So write it down so you don't forget
85	Shahar	What is your reasoning Maya?

After Shaked follows the teacher's order to read the text (57), the teacher bluntly claims, "This is the issue I presented to you" (58). Shaked's position in (61) reflects what the text (and the teacher) indicated should be the solution. However, when Shani says, "in my opinion" (62), the teacher immediately rejects her initiative by saying, "Now, there is your personal opinion, and there is the opinion that you represent in the interest group" (63). Again, the instructions shape the interactions as an actant. The teacher serves as the instructions' gatekeeper and delegitimizes Shani's opinion. The teacher keeps requesting additional reasons that strengthen the interests of the residents "Also try to think about the use of an open area that has not been touched and that is completely natural and wild " (65). Despite her request, Shaked tries again to express her complex position (66). The teacher relates only to the part of the position which fits what she understands as the interest of the residents (67). The IRE pattern rules the rest of the discussion until the

teacher feels the students fulfilled what was expected and ends her intervention (84) by "So write it down, so you don't forget."

In this example, we saw that the students began to collaborate by identifying their common interest as residents and then participating in an epistemic practice – they expressed a reasoned position. At that stage, a dialogic network was maintained in the context of dialogic argumentation. This network was immediately dissolved when the teacher intervened in order to strictly follow the different instructions – to integrate knowledge learned in a different discipline in the students' discussion. Therefore, the teacher aimed at triggering an epistemic practice – the integration of knowledge from another discipline, but the network deployed in the interactions between the teacher and the students was not dialogic: the teacher exerted her power on the students, and the instructions functioned as actants that imposed the centrality of the teacher.

The second story of two epistemic practices in classroom talk: Weighing Pros and Cons before taking complex positions, and role-playing in a democratic game

We present here what happened in the group of entrepreneurs on the same second focus day as in the second example (about the exploitation of open spaces in a city). The students in this group start their discussion by looking at the survey results. The actors in this network are similar to those presented in the previous example: five male students, a teacher, and the instructions. However, this network also involves a chart of survey results about the preference of the residents for the partition of the land. We will see in Table 6 that this actant shapes the interaction of the students in what will appear as the deployment of dialogic argumentation.

Table 6. Excerpt 5 showcases the second story of two epistemic practices in classroom talk.

Line	Speaker	Talk
1	Avi	Listen, the majority prefer parks and playgrounds, then open spaces, and rank us, housing, in last place
2	Noam	Right
3	Gal	Are we ranked in last place?
4	Teacher	So we need to consider this? For whom?
5	Avi	No, so we have to consider this, but we manage everything, so what do we care about them?

Avi interprets the survey results and infers that they, as the representatives of entrepreneurs, are in a difficult position (3). In the beginning, Avi suggests ignoring the other stakeholders' positions (5). However, this suggestion is not adopted by the other group members. Instead, as will be shown in Table 7, they came up with two other proposals to accommodate the contradicting needs of entrepreneurs and other stakeholders.

Table 7. Excerpt 6 showcasing the second story of two epistemic practices in classroom talk.

Line	Speaker	Talk
6	Gal	Parks in first place and parks we also build. We are contractors we also build parks
7	Noam	But listen, listen, houses

8	Avi	Parks are in first place
9	Gal	Yes
10	Noam	Look at my diagram, the chart
11	Avi	66% houses because we are, after all, houses are our main source of income
12	Teacher	But a source of livelihood focuses on the side of the contractors, he is right
13	Avi	We need to make money, and (building) houses allow us to make the most money
…	…	*[Turns 14-54 omitted – students repeat their arguments]*
55	Teacher	Now listen to Avi
56	Avi	The one who says that 66% is not possible does not have to spread this 66% horizontally, it can be spread vertically, and then this 9% expands. It takes up less space
57	Noam	But then it's not 9%.
58	Gal	What I'm saying is we'll take 6% off the houses
59	Avi	This is 40
60	Student	Then it came out 60.5
61	Avi	Yes, but you do say 60%, so you don't have to do them all single-family houses. You make everything buildings, you only want buildings

Gal suggests allocating most of the land to building parks (6). Noam reminds the group that entrepreneurs want to build houses (7), but Avi concurs with Gal's suggestion (8). Noam brings an actant – diagram representing the open spaces' exploitation according to the interests of entrepreneurs (10). Gal further explains that entrepreneurs build parks and can benefit financially from this decision. Avi challenges this suggestion by saying that the financial revenue from building housing is more significant than building parks (13). So far, the entrepreneurs have formed a network in which they explain to each other what their interest is. We do not show a long discussion among students during which they weigh the pros and cons of possible solutions. The entrepreneurs co-constructed complex arguments: they would build hospitals, retirement homes, and universities for the sake of all, as well as buildings; by doing such, they show that they take into consideration the interests of other groups. Turn 56 is a turning point. Avi says, "The one who says that 66% is not possible," and refers to other groups of interests. He calls for reinventing the concept of land allocation. Instead of allocating the land horizontally, he offers to build multiple-story buildings (56). This solution provides mass housing that requires a small percentage of land allocation, and it answers the goals of all stakeholders. The epistemic practice he initiates consists in *playing a democratic game*. The enactment of this practice originates from a complex pedagogic design that provides actants, for example, the chart representing other stakeholders' positions. It also provides a sequence of activities: the students were told that in the next activity, they would need to convince other stakeholders and reach an agreement on land allocation. They feel they cannot take most of the land, yet they must achieve other stakeholders' acceptance to build many apartments. The process of weighing arguments and counterarguments leads Avi to suggest the creative solution of building vertically. This instructional design facilitates two-sided argumentation that considers multiple positions (Nussbaum, 2008; Tsemach & Zohar, 2021). One-sided disputative argumentation will hinder the students' chances of "winning" the game. Instead, they are expected to formulate arguments and suggestions to address the needs of other stakeholders, such as building tall residential buildings.

Nevertheless, there is more in the participation of the epistemic practice of role-playing in a democratic game: The students shape their roles in the game. Avi and Gal suggest redesigning the activity when proposing suggestions not aligned with the official instructions. Gal's and Avi's roles are *translated* through the interaction between different actors; their roles are not pre-given. The students not only play the role assigned to them, the strict role of entrepreneurs pursuing their interests but their roles are also translated into activity designers. Their role is not prescribed; they are negotiated and manifested through the network's interaction.

During their conversation, the students do not rely on previous units (mathematics, philosophy, and science) to build their arguments. Consequently, Teacher 2 stopped the students' conversation about land allocation and asked them a series of questions to lead them to incorporate arguments from other disciplines into their discussion (Table 8).

Table 8. Excerpt 7 showcasing the second story of two epistemic practices in classroom talk.

Line	Speaker	Talk
86	Teacher 2	To which text of the world's creation does this idea of massive construction correspond to you? The Egyptian or the African text?
87	Noam	The second
88	Gal	The African
89	Teacher 2	The African?
90	Noam	Man builds things by himself
…	…	*Turns 91-103 omitted*
104	Teacher 2	What is more controlled there? They tell you that man is responsible for the entire social order, the structures, and the infrastructure, and he is actually equal to God because he was created from God's tears, right? So, man equals God equals order. So, is this order a social order? Natural order? Of flora and fauna? This is the text you need to base yourself on
105	Avi	I think that would be the best way (how to allocate the percentage)
106	Gal	Ok. We are in first place

Like in the previous example, the instructions serve as actants that shape the interaction: Teacher 2 functions as their gate keeper. Teacher 2 is determined to fulfill all pedagogical goals and uses an IRE turn-taking sequence of interactions to introduce arguments that incorporate knowledge from the disciplinary lessons in students' mouths. However, the students do not participate in this epistemic practice (of integrating knowledge from different disciplines). Immediately after the teacher finishes recalling what was said in the philosophy session (103), the students discuss land allocation without further referring to what was learned in mathematics and science. Such a reference seems artificial to them and is not incorporated into the discussion because it does not serve the students' main goal - formulating a proposal that will convince other stakeholders to give high-rise building rights. This example demonstrates, again, how an educational design and its interpretation by the teacher can dissolve a dialogic network. The teacher is determined to incorporate arguments learned in other disciplines even if it stops the dialogue among students.

After this activity, each group received five minutes to present its suggestion to the class. The entrepreneurs presented the idea of building multiple-story buildings to save the land and other arguments

in favor of filling other civic needs by building centers such as hospitals, retirement homes, and universities. Due to the lack of time, the presenters did not develop their arguments. Following the presentation, the students were divided into groups of different stakeholders and asked to agree on land allocation. We show here a short excerpt from one of the heterogenous groups of stakeholders. The idea of tall buildings, once ignored by the second teacher, is now adopted by her. The protocol in Table 9 shows that the teacher now offers this creative idea to bend the game rules to reach an agreement.

Table 9. Excerpt 8 showcasing the second story of two epistemic practices in classroom talk.

Line	Speaker	Talk
2257	Teacher 2	Fellows. Please, let's go on
2258	Noam	Let's just split it 40% and 40%.
2259	Avi	Ok. Good
2260	Teacher 2	Can the proposal to build multiple-story buildings that accommodate more people and not hurt nature work for you?

This excerpt demonstrates how the epistemic practices of playing a role in a democratic game and creating complex positions are facilitated and hindered through the interaction of multiple actors. The teacher did not embrace Avi's idea of multiple-story buildings in the previous activity because she was more concerned about fulfilling other educational goals: integrating ISD arguments and ensuring all groups have time to present their cases. In this network, the groups consist of different stakeholders that are expected to reach a compromise. Now the teacher finds Avi's creative solution suitable to help the students agree and compromise. The knowledge created in one network roams to other networks. It can be ignored or embraced according to the interactions of different actors.

The third story of two epistemic practices in classroom talk - Taking a reasoned position and integrating knowledge from different disciplines

The protocol is taken from the first focus day that presents the question of whether to insert DNA information into biometric data for passport control uses. The protocol shows excerpts of the interdisciplinary session that followed the disciplinary sessions on how to encode texts in an encrypted way (in mathematics), DNA (in science), and human rights (in philosophy). These sessions were designed to provide resources for the interdisciplinary session. Like in the previous example, we will describe the deployment of a network. In this network, multiple actors interact. The human actors are Teacher 1, Teacher 2, and 20 students. The non-human actors are instructions: (a) take a position about inserting DNA information into the biometric passport, and (b) use what was learned in the disciplinary lessons to justify the position chosen. The teacher begins the interdisciplinary session by asking the students to take a yes/no position (Table 10).

Table 10. Excerpt 9 showcases the third story of two epistemic practices in classroom talk.

Line	Speaker	Talk
1	Teacher 1	Now there is a question that comes up in court discussions. Do you know that biometric passports are issued?
2	Students in chorus	Yes
3	Teacher 1	Should we put in the question being asked, insert information from the DNA, the question that now comes up for discussion, are you listening […] The question is whether to insert information from the citizens' DNA into the biometric passport?

		This question is now being debated in the courts in Israel. I want to hear your opinion about the question. Today, biometric passports are commonplace. It is the passport without the pages
4	Benjamin	I did it
5	Teacher 1	Ok, we want to insert information from the DNA. But each person's DNA is unique, except for identical twins
6	Benjamin	There is another table (explaining DNA and RNA)
7	Teacher 1	The question is, I want you to tell me whether you are for or against it, but to give me a reason, a scientific reason, or a reason from what you have learned. The biometric passports?
8	Benjamin	Yes
9	Teacher 1	Should you put your facial features in there, your DNA information? Should you enter this information? It is not information written inside some chip. [Are you] for or against, Bar?
10	Bar	I am against it because you can lose your passport, and then let us say someone finds it, I do not know, a criminal, let us say, and then he can use your details from the DNA for things
11	Ely	But also, with a non-biometric passport, there is a risk of identity theft
12	Bar	Yeah, or break into your privacy or stuff like that
13	Rotem	He cannot, it's your DNA
14	Teacher 1	So wait, Bar, you are against it?
15	Bar	He can hack his DNA
16	Benjamin	Because it's possible to enter
17	Rotem	That's not true because if he tries to enter with his DNA, it won't be the same. The DNA won't be
18	Teacher 1	Bar is against
19	Bar	He cannot
20	Teacher 1	Because she says if I
21	Bar	Like no, he won't steal my identity, he'll be able to use this information
22	Sarah	He will not have access to the information because if he enters DNA in order to enter the information, he will have to enter his DNA
23	Rotem	And if it turns out someone, I don't know, who knows how to break into all the repositories
24	Ely	DNA?
25	Bar	But even a normal person can break through
26	Rotem	No, but it's specific to DNA, not to...
27	Bar	DNA no, it's harder to break
28	Teacher 1	Daniel, what are you saying?

| 29 | Daniel | I actually wanted to say what she said. It's just so easy to lose something like a passport, especially, and anyone can |
| 30 | Teacher 1 | So, you say what Bar said. Thanks. Liat, what are you saying? |

This example demonstrates the deployment of the epistemic practice of taking a reasoned position in a dialogic argumentation. The conversation which develops in this protocol is now more equally distributed as many students participate in it and interact among themselves. A dialogic network is constructed, as nobody is subjugated to other actors, the teacher, or the instructions.

After introducing the topic for discussion (3,7), Teacher 1 asks the students to take a yes/no position (9). Bar expresses a reasoned position (10), which is elaborated by Ely (11) and challenged by Rotem (13). Dialogic argumentation is initiated in which the epistemic status of Bar's argument is at stake. The teacher, who dislikes this incertitude, requests Bar to stick to a clear position (14). However, the students ignore her and continue their dialogic argumentation (15-17, 19, 21-27) despite the teachers' interventions to state their positions (18, 20, 28, 30). There is no consensus among the students, and they try to challenge each other's positions. The students focus on the questions of identity theft and stealing private information.

The network shifts in a different direction when Doron, one of the students, asks Teacher 1 for an example of a supporting reason for biometric passports (Table 11).

Table 11. Excerpt 10 showcases the third story of two epistemic practices in classroom talk.

Line	Speaker	Talk
31	Hila	Someone said identity and anyone could hack into your personal information. Let's say
32	Teacher 1	Wait, Doron can't hear you at all, and it's a shame
33	Doron	Teacher 1, you didn't explain [inaudible]
34	Teacher 1	What? Are you in favor?
35	Doron	Yes
36	Teacher 1	For example, someone who is a terrorist... A terrorist, today you can tell by his facial identification (identify a certain person by facial recognition), catch him already at the airport on the way to an attack. For example, this protects me; it is an argument in favor. Yes
37	Hila	So, let's say someone is a terrorist, let's say someone is a terrorist. He can't get a passport because no one will issue one for him, he can't, he's not allowed to pass because... let's say, someone, I don't know, someone who was released
38	Teacher 1	I need to check this, what Teacher 2, someone who is a criminal, is not issued a passport?
39	Teacher 2	Listen. First of all, you are right. Everyone has a passport. It doesn't matter if they're a terrorist or not, ok? But if now that person is considered a terrorist, ok? He arrives in the country; they can tell him, 'Listen, we won't let you in.'
40	Teacher 1	Using the facial features that are in the database
41	Teacher 2	Not just the facial features, but in general, his fingerprint, according to the retina of the eye, or even according to his DNA test. Ok? They can tell him, 'you are not coming in.'

42	Teacher 1	But it protects us

Doron asks Teacher 1 to give a reason supporting the insertion of DNA (32), and Teacher 1 presents a reason to support a biometric passport – biometric data can help border control identify and prevent terrorists from infiltrating the country (36). Hila challenges and modifies the reason given by Teacher 1, suggesting that no one will issue a passport to a terrorist (37). Teacher 1 approaches Teacher 2 for help. It appears then that Doron and Hila's comments lead Teacher 1 to introduce a new actor in the network. Teacher 2 provides information (39, 41) to Teacher 1 and the students.

We will see in the following that Teacher 2 will end the epistemic practice of taking a reasoned position in dialogic argumentation and, at the same time, will initiate another kind of network. To understand his moves, we should say that handling Interdisciplinary Societal Dilemmas involves different disciplines. As shown by Koichu and his colleagues (2022), the program was designed to afford Interdisciplinary Dialogic Argumentation. To this end, we preceded discussions on ISDs with disciplinary sessions that prepared the students for the interdisciplinary session. In a session in mathematics, students learned methods to encrypt information and how these encryptions can be broken. In a session in science, students learned about DNA and that everybody has a distinctive DNA signature. In a session on philosophy, students learned about relations between the individual and society through texts by Rousseau (who stressed the common good) and Locke (who stressed individual rights). The issues raised in these disciplinary sessions were considered relevant to the ISD. The question was whether students would use what was learned in these sessions in the interdisciplinary session. The pedagogic goals and instruction aimed to achieve this goal. However, students' actions are manifested through interaction with other actors in the network. So far, students have participated in dialogic argumentation in a dialogic network but did not capitalize on the disciplinary sessions. They did not spontaneously incorporate disciplinary knowledge. At least not explicitly. In this situation, Teacher 2 decided to remind the students what was learned in the philosophy session (Table 12).

Table 12. Excerpt 11 showcases the third story of two epistemic practices in classroom talk.

Line	Speaker	Talk
43	Teacher 2	By the way, I want to… just for a second. Those who were in the philosophy group, think about the two philosophers in this context that Kalanit is talking about. One philosopher Rousseau said we need the common good, ok? The common good comes before the individual. Ok? The group, the majority, decides. John Locke said that the individual comes first. I am what matters. So, think when you argue for and against, what, why, what, a second, who is more important in this matter? Try to do who says what, as if you were talking from his throat
44	Teacher 1	Ah yes
45	Liat	But I'm not done
46	Teacher 1	Oh sorry, wait
…	…	*Turns 47-61 omitted*
62	Rotem	These things are inside the passport to protect it. That also means his privacy but also a protection system. In the same protection system, it is impossible to fake
63	Teacher 1	So, you are saying that it can help us because it is another means of protection
64	Rotem	Protective measures
65	Teacher 2	But protection from whom?

66	Benjamin	About your details, about everything
67	Teacher 2	Yes, but for whom?
68	Rotem	Me
69	Hila	But Rotem, I wasn't talking about identity theft. I was talking about, let's say, he lost his passport. It can reveal the details of where he lives, his name, and then he
70	Rotem	He can't because his details are saved inside the card. To get inside the card, you need DNA and facial recognition or things, so it's impossible
71	Hila	But he can know his name and where he lives
72	Rotem	You need facial features
73	Hila	Even according to the passport without DNA
74	Teacher 2	Rotem, yes
75	Rotem	I said
76	Teacher 2	You said very [inaudible] things. I want to ask a question and refine it a bit so everyone will understand. When you talk about protection, it's actually your details that are now in a repository, ok? An international, national database. Who are they meant to protect?
77	Rotem	They come...
78	Teacher 2	Second, I will give you the option to make it easier for you to tune in. Your details are here to protect you as an individual, ok? As a citizen of the State of Israel, OK? It's to protect the country, ok? And it doesn't matter what country you live in, ok? Whom does it come to protect, and for whose benefit does it come to protect?
79	Rotem	It came to protect me and for my benefit, but because it's my details, my things, but in the same situation, if, say, a terrorist steals it, it will still protect him, and he still won't be able to steal it, I mean it still protects the majority
80	Teacher 2	I will present a case here
81	Rotem	He still can't get in with it
82	Teacher 2	I'll give a case here, ok? I'm sick now, ok? In an international database, it is written that I am sick with some kind of disease. I now want to go visit Switzerland. I came to the border crossing. They told me, 'Sir, you are sick. You can't visit us. Go home'. So now my question is, whose data is stored in an international database, and whom does it protect? Does it protect me or the state? I really, really want to visit Switzerland now.
83	Rotem	(It protects) the state and you
84	Teacher 1	Ok, what do you say Tomer?
85	Tomer	About the *** (inaudible)
86	Teacher 1	No, about what came up (in the conversation)?
87	Tomer	First of all, one is that, it's for good, it's not for good, the good of everyone, including my own personal good, the prevention (of sick people from entering the country) because if it's a disease that can really infect people, it's for the good of the whole, but if it comes *** (inaudible) on the passport, it's for the good of everyone

88	Teacher 2	Let's say, my disease is not contagious
89	Tomer	So there is no reason
90	Student	Like, what kind of disease?
91	Teacher 2	Diabetes. It is not contagious
92	Student	So why not let him in?
93	Teacher 2	They don't want to let him in. The Swiss government is determined that anyone sick with such diseases with this body temperature cannot enter Switzerland
94	Student	But why?
95	Teacher 2	I will also say why. They decided they didn't feel like taking care of people. They didn't feel like taking care of people. I did declare that I was coming to travel for a week, but in the end, I'm coming, I'll tell you a secret, I'm coming there for ten years. Now, if I'm sick, who should take care of me? The Swiss health system. And they say, listen, we don't want to treat a second-class citizen

This protocol shows how the epistemic practice of taking a reasoned position in dialogic argumentation fades out to the benefit of integrating knowledge from different disciplines in guided classroom discussion. Teacher 2 brings forward what was learned in the philosophy session, Rousseau's *Social Contract,* and Locke's *Treatises of Government* to show the tension between the common good and the individual's rights (43). Teacher 1's "Ah, yes" indicates that she forgot this instruction. However, this invitation to integrate knowledge from the philosophy session is rejected by Liat "But I'm not done" (45). Teacher 2 respects her will to continue expressing her thoughts without being disturbed (Sorry), in (46). We do not show the continuation of the dialogic argumentation among students.

Turn 60 is a pivot in the discussion as Rotem refers to "protective measures". Teacher 2 interrupts him to bring to the attention of the other students the issue of protection – "Listen to what he has to say. He may say things of interest". In (62), Rotem expresses the idea of protection again and adds the idea of privacy, and in (63), Teacher 1 interprets the student's turn as "it can help us because it is another means of protection." In turn (63), Teacher 2, who understands that the discussion blurs the boundary between the protection of the individual and society, asks, "protection from whom?". In (67), he modifies his question as "protection for whom," to which Rotem answers in (68), "me." Here, we see a succession of turns in which Teacher 2, who failed at explicitly integrating what was learned in the philosophy class in (42), does so implicitly (67).

Indeed, the students implicitly express philosophical ideas they learned in the philosophy session without the help of the teachers. As for the ideas of theft of identity, protection, and privacy, they are alluded to by the students. The teachers only help articulate them as a tension between the individual and society, an idea introduced in the philosophy session but could be integrated into the network only when it became relevant in the flow of the discussion. The instruction to integrate knowledge learned in the philosophy session is an omnipresent non-human actor as it directs Teacher 2's actions: in (78), he states, "to protect you as an individual, or to protect the country?".

However, Teacher 2 gradually focuses more often and in longer turns and becomes the dominant actor as he changes the topic of discussion according to his interpretation of the instructions. When doing so, he puts aside the dominant epistemic practice of taking a reasoned position in dialogic argumentation by enacting a guided discussion in which he is the center. In 82, he alludes to an international database and asks, "whom does it protect? Does it protect me or the state?". When asked why the good of the state

is not necessarily the good for all (in 87 and 94), Teacher 2 declares, "They [the state] decided they didn't feel like taking care of people […] And they say, listen, we don't want to treat a second-class citizen". We see that the integration of disciplinary knowledge in the ISD is led by Teacher 2 in a network that stopped being dialogic, as he dominates the other actors.

The arrangement and dynamics within a network affect the flow of information, ideas, and students' agency. At the beginning of the discussion, the students created arguments when they were involved in dialogic argumentation. Yet, they did not explicitly incorporate disciplinary knowledge from previous networks spontaneously. Teacher 2 seems obligated to achieve this goal. He presents a case and series of questions that aim at leading students to incorporate disciplinary knowledge (88,91,93,98). However, when doing so, he becomes the main focus, the source of knowledge dissolves the dialogic network, and a teacher-centered discussion emerges. The change in epistemic practice from taking a reasoned (disciplinary) position to integrating knowledge from different disciplines is accompanied by a change of network – from dialogic to monologic, in which actors (humans and non-humans) are different, as well as the source of knowledge.

This example demonstrates similar interactions and epistemic practices as in the third excerpt (Table 4). In both examples, in small-group activity and classroom discussion, the contradicting instructions function as *Immutable mobiles*: The instructions were created in a previous network, the circumstances of their creation were forgotten, and now they exert power and shape the interaction in other networks. The instructions function as actants that dissolve a dialogic network. The dynamics hinder the original educational goal of promoting students' argumentation toward expressing reasoned positions.

This example demonstrates that teachers' roles are not given in advance; they are *translated* in certain interactions with human and non-human actors. At the begging of the discussion, Teacher 1 facilitates the discussion among students and enables them to create and challenge arguments. At the end of the discussion, Teacher 2 is a source of knowledge who tries to lead the students to a pre-given conclusion. Their roles emerge in the complex interactions between humans (students, other teachers) and non-human actors (multiple instructions). Their roles also change the dynamic and epistemic practices in the network.

Discussion

This research aimed at identifying advancements in epistemic practices in the classroom and small group discussions around Interdisciplinary Societal Dilemmas. We asked which epistemic practices are advanced in such a program and aimed to recognize how these practices are deployed in time. We identified four main practices: (1) taking a reasoned position, (2) integrating knowledge from different disciplines, (3) weighing the pros and cons before taking a complex position, and (4) role playing in a democratic game. We claim that the emergence of these practices was afforded by a program designed for promoting interdisciplinary dialogic argumentation around ISDs.

Indeed, students expressed reasoned positions and preceded their expression by weighing the issues at stake in the resolution of ISDs (see Second Story, Table 7). The explicit integration of knowledge from different disciplines demanded concerted efforts from the teacher, but implicit integration could be detected. The social construction of knowledge happened in small groups of students whose agency was high, although the presence of the teacher sometimes inhibited the co-construction of knowledge (First Story, Table 5; Second Story, Table 8). Role-playing was not achieved to pursue interests and aims that corresponded to the roles assigned. Instead, students played roles by considering the interests and aims of other players with other roles – by participating in a democratic game (see Second Story, Table 7). As for the second part of the research question, how these practices were deployed in time, we would suggest

first factors contributing to the enactment of these epistemic practices and their advancement, then specific interactions that were somehow unpredictable.

We claim that the factors responsible for this success are twofold: the contents of the program – the Interdisciplinary Societal Dilemmas (ISDs), and the program's design. ISDs are similar to Socio Scientific Dilemmas (SSIs). The issues they raise are relevant to society and involve the consideration of many perspectives. However, in contrast with SSIs, which are tools for advancing engagement and knowledge in science (Sadler, 2009), ISDs are not aimed at advancing any knowledge domain but at engaging young citizens in real problems whose scope is societal (Schwarz et al., submitted). The interdisciplinarity of ISDs stems from the complexity of real-world problems. We suggest that this authenticity confers to ISDs the potentiality to raise the desire to know because knowing in the case of ISDs is useful and has an ethical dimension.

The program we developed focused on the ISDs. It relied on a principled design aimed at affording *interdisciplinary dialogic argumentation*. These principles, which are partly theory-laden and partly rely on empirical studies, are documented elsewhere (Koichu et al., 2022; Schwarz et al., submitted). They demanded enormous efforts at multiple levels (curricular, organizational, and institutional). Without such a design, the program could not have been implemented. That being said, the gap between the design for argumentation and the talk induced by this design is generally wider than for the design of other educational practices because dialogic argumentation leaves much freedom to participants (Schwarz & Baker, 2016).

To a large extent, this gap was analyzed based on concepts of ANT. ANT helped describe unpredictable interactions that deployed in classrooms. Educational practitioners and researchers aspire to develop learning activities that foster specific goals. ANT-based analyses exhibit the complex and unexpected links between different actors within a specific network and the relations between different networks. Mapping the different actors, human and non-human, and how they interact with each other through time reveals how some of the educational goals are not accomplished and sometimes contradict other goals. A process that otherwise could have remained a 'black box' (Latour, 1999) was disassembled into its various components and thus uncovered the ways teachers and students interpret and navigate around the various goals that create tensions in enacting epistemic practices.

For example, we found that the designers' goal to enable discussions among students about inserting DNA information into biometric passports led the teacher to interpret her role as a facilitator of yes/no one-sided reasoned positions (Third Story, Table 10). This interpretation hindered the goal of the students – to weigh the issues at stake for this ISD seriously before expressing their reasoned position. It seems that the teacher preferred certain positions, which can hinder conceptual development and sophisticated argumentation. This phenomenon resonates with research done by Chen and colleagues (Chen et al., 2019; Chen, 2020; Chen & Qiao, 2020). Also, the way the teacher interpreted the goal of the residents in the exploitation of open spaces in the development of a city for creating parks (in the third example) hindered the students' pursuit of the interest to balance between lodging needs and leaving room for domesticated nature (First Story, Table 3). This phenomenon could be described through the kinds of networks that developed – some being dialogic and some not. The dialogic networks – those in which human actors were not subjugated to other actors (human and non-human) were frequent. In those networks, students expressed reasoned arguments and interacted with each other in what seemed to be dialogical argumentation. We saw that such dialogic networks often disappeared when the teachers intervened and imposed instructions on them (according to their interpretations) or their position on the ISD. Nevertheless, we saw that the teachers often *translated* their role from instructors as knowledge transmitters to facilitators and vice-versa.

ANT could then discern between dialogic and non-dialogic networks and roles played by actors: Students' and teachers' roles were re-translated in the shift between dialogic to monologic networks. In the dialogic networks, the teachers functioned as facilitators and students as knowledge constructors. In the monologic networks, the teachers' role was translated into the primary source of knowledge. Sometimes the shift from a dialogic to a non-dialogic network was so abrupt that immediately after the teachers left, the dialogic network continued from where it last stopped without affecting the dialogue. More generally, the ANT methodology helped map actors' agency in all networks created. Students or teachers had no pre-defined roles. Actors manifested themselves through interaction with other actors. Students could act as knowledge constructors or educational designers in enacting the epistemic practice. Or they sometimes were absorbers of knowledge when the teacher acted as the primary source of knowledge.

By using ANT methodology, we showed the significant role of *Actants,* non-human actors, in deploying networks: tables, instructions, texts, etc. These actants often exerted their power on the teacher, who took care of the fulfillment of the requested task at the expense of the needs of the students. That is, the agency of these actants was revealed as affecting both the teaching and learning processes and teacher-student relationships. We saw the role of *immutable mobiles* that emigrated from one activity to the other, from one network to the other, and from one session to the other. The protocols we presented exhibited several instances of dialogic and non-dialogic argumentation. Concerning interdisciplinarity – the third vertex of the design to afford interdisciplinary dialogic argumentation, we saw that it hardly happened. When it happened, it was not dialogic: The network deployed when the teacher on the first focus day instigated the use of insights from the philosophy session showed how the teachers imposed on the students the integration of knowledge from another discipline. We saw traces of this type of intervention in a network that was at the boundary between the dialogic and the non-dialogic. However, in general, interdisciplinary dialogic argumentation did not happen. In this paper, we could not show this general claim, but in another publication (Schwarz et al., submitted), we provide a systematic description of the interdisciplinary sessions in all focus days and show that the autonomous integration of knowledge from different disciplines was not reached.

In spite of the difficulty to integrate knowledge from different disciplines, we could say that, all in all, the discourse deployed in the focus days showed the remarkable agency of the students most of the time. Although we did not expound on the design principles here, we could say that we cultivated two-sided argumentation in our design tasks. It was not difficult in the case of ISDs, which presented many opportunities for the emergence of conflicting arguments. Two-sided argumentation is essential to develop students' reasoning and promote civic and democratic discussions. Nussbaum (2008) showed how learning tools facilitate students' ability to incorporate arguments and counterarguments in opinion essays. Although such diagrams are not presented in the examples we showed, we often used diagrams like his. Our insights offer an educational design that facilitates students' two-sided argumentation in classroom dialogue. As public discussion has become more polarized in recent years, some educational institutions still cultivate one-sided eristic argumentation that hinders students' participation in democratic civic discussions (Tsemach & Zohar, 2020). Our carefully crafted program proved that students could engage in civic discussions where different voices are taken into account and reach a compromise, a goal articulated by theorists (Cohen, 2020; Walton et al., 2008), but whose instantiation has not been evidenced so far.

While the educational design was not fully successful in affording the integration of students' knowledge, it was very successful for the three other epistemic practices we listed above: taking reasoned position, weighing pros and cons before expressing a complex position argument and playing a role in a democratic game. For example, including role-playing in a democratic game where students were required to consider other stakeholders, persuade them and reach an agreement. This design yielded two-sided argumentation as students offered creative out-of-the-box solutions that answered the interests of different

parties. Sometimes, the students who represented entrepreneurs acted as activity designers when they challenged the game rules, as in the example when one of the students rejected dividing the land into 100% rights for building and other causes. Instead, he offered to build multiple-story buildings, which freed more land for parks and open spaces. The ANT analysis also traced how the teacher ignored this solution in a small group activity when it did not align with the teacher's educational goals. Then in the last activity, it was embraced and used by the teacher because it served her needs.

In a brief review of research on epistemology in the *Learning Sciences*, we have stressed that research on epistemology as a social practice is a burgeoning direction besides the personal and disciplinary perspectives. In light of our use of ANT to analyze talk around the resolution of ISDs, we claim that ANT is a forceful methodology for studying the advancement of epistemic practices in classroom talk. Since it holistically reveals a variety of elements involved in creating dialogic and non-dialogical networks. Therefore, it seems that the advantages of this method are in highlighting the conditions through which it is possible to enable and create dialogic learning environments and avoid dialogue barriers.

Our success in advancing epistemic practices in solving ISDs through dialogic argumentation has educational implications. Beyond applying the design principles for elaborating programs around ISDs, we believe that the ANT methodology, which was adopted for research goals, may have educational repercussions. Introducing teachers to the basic concepts of ANT, together with authentic examples, can help them better interpret learning situations and make better choices in practice to achieve their pedagogical goals. Exposing teachers to the idea that different actors interact in ISDs activities – human and non-human, is not far-fetched. This is especially important in an era of technological developments in education. More so, bringing teachers' attention to the agency of these actors is an accessible idea. In general, the more teachers and students are aware of the actors involved in creating (the networks of) the learning processes, the more they can choose how to participate and learn together. Moreover, conveying the idea that when interacting with their students while engaging in ISDs, they form networks, some being dialogic and some not, is an idea that can easily be grasped. More research is needed to explore how ISDs provide opportunities for educational design, interdisciplinary dialogic argumentation, and professional development.

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