Chapter 27
STEPWISE as a Vehicle for Scientific and Political *Educ-action*?

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27.1 Introduction

In contemporary society, interactions between science, technology, technoscience and society are pervasive. Socio-Scientific Issues (SSI) education was developed in response to this situation and has become one of the main contemporary trends in science education. But it is possible to distinguish different variations related to SSI education; among others, variation in educational stakes that can 'cool down' or 'heat up' these issues (Simonneaux, 2013). Science and society are now seen as mutually interdependent in an educational context. The orientation of European programmes such as U FP7 and Science & Society programme and Horizon 2020 illustrate this. One of the goals of science education is to help students develop their understanding of how society and science are mutually dependent. This is the educational school of thought known as 'Science-Technology-Society' (STS) and, for several decades, the study of socio-scientific issues education has developed along these lines. The origin of the STS movement can be traced back to the 1930s and was led by scientists into the field of science education. It immediately fell in line with the citizenship education trend (Hogben, 1942). In Great Britain, after the Second World War, two movements had an influence on the promotion and development of STS education: the first was initiated by scientists who felt a sense of responsibility towards the public in view of the environmental impacts of scientific and technological developments, such as nuclear weapons and pesticides; the second movement was much weaker and aimed to break down barriers between the 'two cultures', the arts and science (Ratcliffe, 2001). Encouraging individuals to take a personal position was a major challenge for STS education: « In traditional

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science instruction personal opinion is not involved and may be actively avoided. STS instruction, on the other hand, seeks out exchanges between students to help them arrive at personal positions that combine scientific knowledge with moral responsibility » (Solomon, 1981, p. 78). The STS movement was revisited by Derek Hodson (2003) who integrated the environmental dimension and became a campaigner for the development of STSE education in order to incite students to engage in decision making and action.

Alain Legardez and Laurence Simonneaux coined the term *'Questions Socialement Vives'* – in English: 'Socially Acute Questions' (SAQs). These questions are 'acute' in society, in research and professional fields, in classrooms and are often discussed in the media. The field of SAQs represents a French orientation to the teaching of SSIs. But SAQ instruction is part of the educational movement which advocates the study of the interactions between Sciences-Technologies-Societies-Environments (STSE). This study supposes to acknowledge the links that exist between sciences, politics and business.

Liora Salter (1988) uses the term mandated science, John Ziman (1996) post-academic science, Sheila Slaughter and Larry Leslie (1997) academic capitalism. The sciences have "*entered into a polygamous union with the economy, politics and ethics*" (Beck, 2001, p. 53). This raises the question of the moral responsibility for uses of scientific applications. Society? Scientists? Technologists? State? Jerome Ravetz (1975) raises this issue in his own way: "*Scientists take credit for penicillin, but Society takes the blame for the Bomb*" (p. 46). Knowledge and nature itself found themselves as 'goods.' That is to say, turned into salable and purchasable things. Parallel to development of science and the technosciences, in 1994, in the context of the 4th EU Framework Programme, ELSA was introduced as a label for developing and funding research integrating the Ethical, Legal and Social Aspects of emerging sciences and technologies. Currently, particularly in the context of EU funding initiatives, such as Horizon 2020, a new label has been forged, namely Responsible Research and Innovation (RRI). We are not going to summarize here the analysis carried out by Hub Zwart, Laurens Landeweerd, and Arjan van Rooij (2014) about this semantic shift. They consider that "*the newness of RRI does not reside in its interactive and anticipatory orientation, as is suggested by authors who introduced the term, but rather in its emphases on social-economic impacts (valorisation, employment and competitiveness)*" (p. 1). These labels (ELSA, RRI) indicate that the political sphere has understood the need to take into account social and societal aspects of the development of the technosciences in order to avoid a rejection by society, as was the case in France with GMOs. This is typically what has been done as soon as the first concerns about nanotechnologies were expressed. The goal is to prevent public controversy to hinder innovation. ELSA or RRI labels reveal the great importance of humanities and social sciences in the (Techno)Sciences – Societies interactions.

In science education, the notion of SSI has been introduced as a way of describing social dilemmas impinging on scientific fields (Zeidler, Walker, Ackett, & Simmons, 2002). Within SAQ education, the educational challenge is to enable students to develop informed opinions on these issues, to be able to debate such issues, to be capable of making choices with respect to preventive measures and intelligent use of new techno-sciences (Simonneaux, 2006). In order to solve most problems

arising in contemporary society, scientific solutions alone are not enough and considerations must be given to the social implications of decisions relating to scientific investigations (Sadler, Chambers, & Zeidler, 2004).

SSI/SAQ education contributes to the 'educations for': (scientific) citizenship education, sexuality education, education for health, education for safety, education for the environment and for sustainable development. 'Educations for' focus on complex issues involving uncertainties that inextricably associate questions of a scientific, and social nature along with values and ethics. SAQ education raises the problem of teaching and learning in an uncertain world influenced by development of techno-sciences and environmental and health crises. These questions situate social and scientific controversy, complexity, building of expertise, assessment of evidence, and uncertainty and risk at the very heart of teaching-learning processes. It is not only experts who make decisions on SAQs; all citizens are involved (consumers, voters, legislators) (Simonneaux, 2006). Not only is it not possible to make just one valid and rational decision, but conflicting interests may lead to divergent decisions.

An SSI-oriented approach provides the motivation that students often do not find in traditional science education. This approach gives meaning to learning, makes operational the abstract concepts of science and promotes students to make connections between concepts. Nevertheless, it has been shown that teachers 'heat up' or 'cool down' SSIs, according to the questions that are under discussion, according to the educational risk that they are prepared to accept and according to the rationality to which they subscribe.

At the 'cold end', teaching about SSIs is used to motivate students to learn science, or even to convince them of merits of technosciences. At the 'hot end' of the continuum, teaching foci go beyond the purpose of developing science conceptual and procedural knowledge to the nurturing of activist commitments amongst learners. Pioneers of the 'activist' movement have developed a framework called STEPWISE (Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments) for organizing teaching and learning in science and technology[1]. The STEPWISE program aims to promote social and environmental justice and tries to foster a desire for change as well as a sense of responsibility (Bencze, Sperling, & Carter, 2012). Bencze (2000) suggests that students work on student-directed and open-ended research projects. This involves getting students to work on projects based on their own research to provide information on socio-scientific issues and encouraging them to make their results public by way of socio-political action (for example, organizing demonstrations and exhibitions, posting militant videos on YouTube™).

Between these two ends, there is a continuum of educational stakes. These range from learning stabilized scientific concepts underlying the issues addressed, developing a capacity for critical thinking and decision-making, learning about the nature of scientific knowledge and taking part in high-level cognitive procedures (identifying the conflicting interests of stakeholders, evaluating risks and uncertainties, generating debate and pinpointing fallacies, cultivating socio-scientific reasoning, identifying the actors' values, assessing evidence and critically analyzing research

[1] http://www.stepwiser.ca

methodology). These procedures contribute to development of critical thinking. When critical thinking occurs, foci move towards the 'hot end.' In the current field of French education, where the educational stakes are high, it is asserted that SAQs can develop high-level thinking, decision making and critical thinking with a focus on promoting an engaged citizenship.

Erminia Pedretti and Joanne Nazir (2011) identify and explore six currents in STSE education: application/design, historical, logical reasoning, value-centered, sociocultural, and socio-ecojustice currents. They consider that the latter four can be associated with SSI education. Most of the SSI-based instructions aiming at high level thinking abilities may be referred to the logical reasoning current. According to Pedretti and Nazir, "*the aim of science education in this current reflects a citizenship and civic responsibility emphasis through the transaction of ideas. As such, the dominant approaches are cognitive and reflexive*" (p. 612). Nevertheless, socioscientific reasoning may also be connected to the value-centered current. "Activities within this current tend to target students' moral and emotional identities to stimulate cognitive and moral development. As such, the dominant approaches are affective, moral, logical, and critical" (p. 614). And, of course, the STEPWISE program may be related to the socio-ecojustice current. According to Pedretti and Nazir, "the dominant pedagogical approaches in this current are creative, affective, reflexive, critical, place based, and experiential" (p. 617). The ecojustice current is also a political education (Lowenstein, Marusewicz, & Voelker, 2010).

SAQs are not only encountered in the (more or less stabilized) 'hard sciences' and invariably in the disciplines within the field of humanities and social sciences, but also in the area of social and vocational knowledge. We consider that many different actors take part in knowledge production. These include scientists, citizens, philosophers, professionals and, even, whistleblowers. The epistemological exploration preceding any didactic undertaking thus takes on a particular form because it cannot exclude interactions among actors and the diversity of reasoning involved in economic, political or scientific fields. It is undoubtedly a primary epistemological position to consider that scientific production processes are oriented and are results of interests of the different stakeholders. Consequently, Jean Simonneaux (2011) asserts that the knowledge involved in SAQs can be conceived of as plural (polyparadigmatic) and/or engaged (analyzing controversies, uncertainties and risks) and/or contextualized (observing empirical data within a given context), and/or distributed (constructed by different knowledge producers).

Decisions taken on SAQs cannot be based solely upon scientific knowledge (be it knowledge from the area of the social sciences or the hard sciences) but must also take into account social implications, ideologies and values. Unlike the work on SAQs, the SSI approach is mainly based on the didactics of the 'hard sciences.' Although complexity and uncertainty are recognized in SSIs, the role of interdisciplinarity is rarely studied, nor are concepts of the humanities and social sciences or those of social or vocational knowledge seriously taken into consideration. If we take the example of the controversial question of pesticide use, we can see that over and above the interdisciplinary aspect, it is the production of distributed situated knowledge that enables us to comprehend the issue. Farmers are not merely receivers of innovations designed upstream, but rather the producers and holders of

knowledge distinct from agronomists (Goulet, 2013). There is no more ONE chemical solution designed upstream. "Singularity, and idiosyncrasy would thus be required in the modes of knowledge and management at the expense of "recipes" established by an experimental science that criticized the farmers involved in these movements" (Goulet, 2013, p. 439). Recognition of farmers as producers of knowledge displays a political dimension.

Consequently, the STEPWISE and SAQ approaches may not only contribute to scientific literacy, but they also can develop students' political literacy by including such topics as risk analysis, analysis of patterns of political and economic governance as well as decision making and action. Even though Dana Zeidler et al. (2005) have provided evidence that SSI education is a better way than the STS movement to integrate the Nature of Science, arguments, values and moral judgements, Derek Hodson (2011) has critiqued both of these approaches and asserts that STS and SSI education have given too low a priority to the promotion of critical thinking. He asserts that neither STSE nor SSI-oriented teaching go far enough.

27.2 Modernity/Reflexive Modernization and Education

A way to consider science-society relations and their connection to science education is to situate them in terms of historical sociology.

This amounts to situating education within pre-modernity, modernity, post-modernity patterns. Does the ternary pattern pre-modernity, modernity, post-modernity reflect the progressive emancipation of the individual in society? It is difficult to situate the temporal boundaries of the pre-modernity period: from antiquity to medieval times or up until the Age of Enlightenment. It is based on tradition and/or religion. The beginnings of modernity are sometimes associated with the end of the Byzantine Empire in the fifteenth century or the discovery of America and sometimes linked to the literary dispute between the Ancients and the Moderns in France in the seventeeth century. Be that as it may, what characterizes modernity is the pursuit of the ideal developed by Enlightenment philosophers, that is to say uses of reason to fight against the arbitrariness of the authorities, against prejudice and against the contingencies of tradition. The authorities and tradition are replaced by reason and science which will foster progress based on true and objective knowledge. Max Weber talks of instrumental rationality. Thanks to modern science, Man (sic) should dominate nature. A new mode of production and consumption, capitalism, is established supported by technological innovation. Modernity is associated with an increase in individualization. Education should liberate the individual thanks to rational knowledge. Scientific knowledge is glorified and transmitted via a top-down process. Scientists get a privileged position and replaced the priests of the pre-modern time. There is an unproblematic link between scientific reasoning and social, moral, ethical reasoning.

Modernity is an « ideal type » as defined by Weber, that is to say a theoretical construction that seeks to match with an empirical historic reality. We observe that the following period is more difficult to define, that the authors have proposed different

ideal types (post-modernity, late-modernity, reflexive modernization, advanced modernity, second modernity, etc.). In the twentieth century, philosophers from the Frankfurt School consider that modernity as a project for social emancipation, has not kept its promises. In the process of dominating nature, Man has made himself the slave particularly because of the development of the technosciences. According to Jürgen Habermas, modernity is an unfinished project that humanity should defend and reclaim in order not to lose its humanity.

Others believe that we have entered the period of postmodernity which will finally allow us to fulfill the project of emancipating the individual by freeing us from the last transcendental figures of modernity. Hope for progress is shattered by the excesses of the technosciences (nuclear weapons, pollution, health problems). Hope in the future is replaced by a cult of the present, but also by an anxiety for the future due to concern over the adverse effects of the capitalist model, especially on environments. Links between science and society are problematic and complex. That scientific research, cultural norms, socio-political contexts, applications influence each other is a recognized fact. The optimism of modernity is replaced by skepticism or even pessimism. Relativism develops alongside a recognition of true and objective knowledge. Traditional images of academic science have changed. Trends in sciences are now criticised as being more and more determined by economic interests.

Bruno Latour (1991) seeks to show that the project of modernity cannot ever be realized. It is a project built on two parallel contracts, i.e. the 'social contract' which is the ground for social order and the 'nature contract' which is the ground for modern science. Together these contracts should make it possible to draw a solid line that separates the society from nature. Such a project, however, is caught by contradictions that become evident as soon as we face such 'hybrids' as AIDS and the ozone hole, which are neither nature nor culture, but something in between. Bruno Latour considers that all cultures have produced hybrids. The specificity of this epoch is based on two things: (i) the scale and the threatening nature of our hybrids, (ii) their existence calls into question modern attempts to draw a solid line between nature and culture. According to him, the time line of modernity and its by-product, progress, is not straight. We have never been modern because we have never progressed towards increased efficiency and profitability. "The old idea of progress, the one we recently abandoned, let us stop being wary, let us throw caution to the wind. The new concept appears rather to oblige us to be cautious, to make selective choices, to meticulously consider all the possibilities" (Latour, *Le Monde*, 24 août 1996).

Ulrich Beck refuses the post-modernist approach; he considers we have entered a new modernity, but we are still within modernity. We have moved from an industrial modernity to a reflexive modernity. He calls this era the 'risk society.' Beck (1986/2001) suggests that these days we are emotionally aware of man-made hazards: society is concerned about the risks posed by techno responses to past problems. The production of new scientific knowledge is to resolve the multiple impacts (waste, pollution, new diseases) that have been generated by technoscience. One could sum up this late-modernity as an epoch during which individuals have become aware to risks, uncertainty, complexity, disorder, distrust of social and scientific institutions and traditional authorities.

Beck postulates that institutions, including science, are struggling with effects of what they have created, and even though they have begun to change. It is necessary that research anticipates the consequences, uncertainties and risks of scientific advances. Using Beck's analysis, in our late-modern society, scientific rationality would not be sufficient to justify any technoscience and would need to be accompanied by reflexive criticism of its impact. The status of experts in science and technology is criticized and the political nature of technological choices is revealed. Beck believes that, faced with the risk society, with crises, with the uncertainty of knowledge, individuals will develop a reflexive modernization, that alternative rationalities will surface and new social movements, a 'sub-politic' may emerge in the interstices of the official society. According to Anna Olofsson and Susanna Öhman (2007), to be defined as 'reflexive, ' people have to show both awareness and some kind of active strategy to handle new risks. But awareness does not implicate always action, far from it, people can remain in a fatalist position.

The risk society approach tends to adopt a critical realist (Bhaskar, 1975) approach, contending that the real social and natural world exists apart from and is independent of human perception and understanding. Thus, human knowledge of reality is fallible and incomplete and is historically, socially, culturally and politically situated. Experts' judgments of risk cannot be objective and neutral.

Beck's works are sometimes criticized as being strictly theoretical, unsubstantiated by empirical work. Mette Jensen and Anders Blok (2008) did a test, in the form of a case study, on the pesticides issue as perceived in Denmark. Their aim was to study whether or not we live in a risk society. Beck is sometimes accused of exaggerating, especially by Arthur Mol and Gert Spaargaren (1993), who advocate an alternative paradigm, called 'ecological modernization,' in which green lobbies are seen to guarantee environmental interests. Therefore risk society does not exist because of ecological progress. In this case, the technoeconomic progress of modernity will happen under the control of ecological progress. During their study, Jensen and Blok (2008) observed that lay respondents had different 'risk habitus' (p. 765); in particular, they were less anxious when they trusted in a form of ecological modernization to guarantee control. « While a majority of lay-people (and a minority of counter-experts) may be said to broadly inhabit a 'risk' society, a majority of experts (and a minority of lay-people) rather inhabit an 'ecological modern' one". These authors consider then that "as a societal narrative, 'risk society' is hence clearly contested" (p. 773).

Anthony Giddens (1994) also rejected the concept of post-modernity. He calls the current era advanced modernity. For him, no knowledge is ever stabilized forever; progress is a myth. For Göran Therborn (2003), 'multiple modernities' coexist; i.e., people from different lives (traditional, modern, late modern) share the same society. This is similar to the position of Mary Douglas (1985) who emphasizes cultural impacts on judgments about risks. She considers that, within a same culture, different groups can have different conceptions of risks. For her, risk judgments are political, moral and even aesthetic. Her theory reflects social biases that influence a person's perception of risk.

According to Douglas (1992), the theoretical construction of any social organization is based on two key dimensions: an internal structure characterising social groups that gives them a definite place, and a hierarchy that delimits the boundaries of each group compared with other groups. Douglas has focussed on very significant relationships between the organizational form of a cultural group and its values. She has identified four organizational types that occur in modes of social participation and cultural principles. These four types correspond to different perceptions of knowledge, nature and risk. She distinguished these types as: the bureaucrat, the individualist, the egalitarian and the fatalist.

Bureaucracy is an archetype of hierarchy. Within this structure of organised social groups people are attached to values such as order, decency and laws. Individuals within this type agree with the authorities and the scientific knowledge of the scientists who advise them. Nature is regarded as robust and adaptable to human disturbance, but there are lines that should not be crossed. This group perceives that, beyond these limits, irreparable damage can occur and the ecological balance may be irreversibly disrupted. This hierarchical type shows a very pronounced risk aversion but when risks are identified this group expects that the State and the experts will find a good solution.

The primacy of the ego is dominant in the individualist type. Among representatives of this type, shared values are those of an enterprising spirit, free competition and individual achievement. Scientists, innovators and entrepreneurs are respected and followed. Nature is regarded as very robust with a self-balancing system that allows it to cope with all situations. The environment is viewed as a homeostatic system that seeks to recover its original state when a disturbance unbalances it. Balance is the steady state of nature and any imbalance is only temporary. This group believes that the benefits of science and technology always outweigh the harm. Such a conception of nature encourages this group to support boldness and innovation in all fields of technology. The individualistic type is rather risk friendly as they see risk is an opportunity to seize so that they can assert themselves and control the future.

Egalitarians promote the primacy of the group. This type of social organization refers primarily to small groups that are formed around an ideal, an ideology or a fight that they think is legitimate. Within this group are found whistle blowers. Values that have the most weight among egalitarians are equality, fairness and justice. These individuals are wary of academics and they call on knowledge produced by the group itself. Nature is seen as fragile and in a very unstable equilibrium. The action of humanity is regarded as harmful to nature and any imbalance is felt as irreversible. Egalitarians accuse participants within a hierarchical structure and especially those with the individualistic structure, of systematically plundering natural resources and threatening the ecological balance and the common good, including future generations. They have an aversion to technological risk.

Groups belonging to the fatalist type are not integrated into society and are without means for organising and developing a structured group identity. It appears that their internal disorganization and subordination to other social groups plunges them into a kind of fatalism. They do not really think much about knowledge, but express

a general mistrust of it. Patrick Peretti-Watel (2001) defines this group as having poorly determined values and that they display fatalism about their condition and the situations they encounter. They have a view of nature as capricious and unpredictable. They perceive ecosystems as changing randomly that are impossible to predict and control. Chaos theory is, according to Peretti-Watel, the best example of this group's view of risk. For them, risk is inevitable and they have to cope with it. Maybe we can consider that fatalists rely on pre-modern notions of fate and lack of control, while egalitarian refer to late-modern notion of reflexive control over risk.

As science experts are mistrusted, everyone has to make his/her own decision. "We have no choice but to choose how to be and how to act" (Giddens, 1994, p. 75). Hence, there are needs for schools to train for action or activism.

According to Gilles Lipovetsky and Jean Charles (2004), a hypermodern society has emerged which is replacing the postmodern society because of an anxiety associated with awareness of serious issues linked to socio-economic, health and environmental deregulations.

SAQs lies within the field of Post Normal Science (PNS), as defined by Silvio Funtowicz and Jerome Ravetz (1993), as a science with strong links to human needs, thereby leading to large uncertainties, major issues, values, and requiring urgent decisions. According to Ravetz (1997), the question 'what if?' justifies strong consideration 'to extended facts'; that is to say, data from sources outside the orthodox research. These authors emphasize that decision processes on the PNS should include open dialogue with everyone concerned. They introduced the concept of 'extended peer community.' It is important to train students to participate within the 'peer extended community.'

In the perspective of reflexive modernization, SAQs and STEPWISE also question foundations of science and rationalist utopias according to which reason and truth emerge from confrontation of ideas. Thus, for Beck (1986/2001), we must go beyond the "*successive attempts to rescue the 'underlying rationality' of scientific knowledge*" (p. 360) implemented whenever science is confronted with failure or adverse effects. In the research cited above, Jensen and Blok (2008) conclude that the real value of the work of Beck might be its 'performative' dimension with reference to Latour (2003). It is in this vein that we consider STEPWISE to be of interest because reflexivity on modernization is not self-evident. STEPWISE advocates the vital importance of raising awareness of this reflexivity through 'educ-action,' in order to ensure that citizens remain vigilant, do not off-load their responsibility by trusting the government to exercise ecological control. How far should reflexivity be developed? Should education promote the exercise of reflexivity about expert knowledge or empower students to generate their own risk knowledges?

Educ-action aims to encourage not only the involvement of students and teachers but also their commitment to individual and collective action, what Beck calls sub-political engagement. In this sense, both the STEPWISE and SAQ movements defend a humanistic, scientific, political and economic education (Table 27.1).

Table 27.1 From modernity to late-modernity

	Time	Main ideas	Science education policy
Pre-modernity	Ancient and medieval thought	Search for patterns in nature. Hierarchical view of society	Elitist. Scholastic
Modernity	17th to early 20th or even until today	Overarching idea of Enlightenment, Science as rationalist. Rationality is superior to other ways of thinking. Logical positivism, Karl Popper	Lay people need to know more science to appreciate and support good policy. Aim to think scientifically. Understand science first then apply to society. There is an unproblematic link between scientific reasoning and social- moral-ethical reasoning
		Empiricism. Mertonian sense of important values of science such as search for truth, objectivity, impartiality, etc.	
Late-modernity	Since the middle of the 20th	Science seen as imbued with power relationships. Link to society is problematic and complex. Science has a role but meshed in economic, political and cultural dynamics. Ideologies, values recognized	Contextual and situated education
		Critical Realism (Bhaskar). Postnormal science (Funtowicz & Ravetz) even relativism. Society of Risk (Beck)	Consideration for complexity and uncertainty
			Socio-scientific reasoning, moral reasoning Controversial SSI Education for Sustainability SAQ Scientific AND political education

Table elaborated with the contribution of Levinson

27.3 Educ-action and Activism

The development of educ-action is not a new trend, we can refer back, for example, to Freire, but it is evolving with the emergence of a late–modernity. Educ-action meets with resistance on the part of teachers particularly because of its ideological and political dimension. Furthermore, this educ-action implies varying forms of commitment that we need to examine.

27.3.1 Teachers Involvement/Resistance and Rationality

"The need for the inclusion of socio-scientific issues (SSI) into science curricula has been generally accepted, but relatively few science teachers have incorporated SSI into their courses. Most science teachers feel that their most important task by far is to teach the principles of science, and any substantive pedagogical changes represent a burden" (Lee & Witz, 2009, p. 931). There is a perception amongst many science

teachers that science education is about the delivery of facts, and that science is value-free (Levinson & Turner 2001). However, some teachers address SSIs out of their own personal initiative and heat up the issues; that is, they 'teach against the grain' (Cochran-Smith, 1991). Some examples of these practices were presented in a symposium at the last ESERA conference (Levinson & Martins, 2013).

One difficult problem is of the neutrality of teachers leading the debates. Thomas Kelly (1986), one of the first researchers who considered using debates for classroom study of controversial issues, postulated four positions that teachers might adopt: exclusive neutrality, exclusive partiality, neutral impartiality and committed impartiality. Those in favour of exclusive neutrality believe that teachers should not broach controversial themes and that scientific discoveries are value-free truths. They subscribe to a positivistic approach that has been widely criticized. There are two main arguments against their position: first, teachers always convey values, if only through the examples they choose; secondly, the task assigned to schools in a democratic society is to train citizens who are capable of debating controversial scientific issues, which means that the school must stay in touch with real life. Exclusive partiality is characterized by the deliberate intention to bring students to adopt a specific point of view on a controversial issue. In this case, teachers ignore contradictory positions or brush them aside as insignificant. They believe that their mission is to provide students with intellectual certainties. Those in favour of neutral impartiality believe that students should debate controversial issues as part of their education to become citizens and that teachers should remain neutral and not reveal their points of view. For some supporters of this position, teachers should remain silent and neutral so as to maintain their authority and should not reveal their uncertainty or ignorance, while others believe they should remain neutral in order not to influence students' argumentation. This position, which is nevertheless quite appealing, has been criticized. It is important that students have the opportunity of comparing their points of view to those of a 'role model' adult such as the teacher. Moreover, as we have said previously, teachers always convey their values, albeit unconsciously and neutrality is an illusion.

Concerning the latter position, an apparently paradoxical position, teachers gave their points of view while encouraging analysis of competing points of view on the controversial issues. This was the position recommended by Kelly. And Hodson (2011) believes that "it is incumbent on teachers to share their views on these matters with students and to make explicit the ways in which they have arrived at their particular position. It is also incumbent on teachers to adopt the same stance of critical reflection and open-mindedness that they demand of their students, and to be willing to change or modify their views in the light of new evidence, a new way of interpreting evidence, a reappraisal of underlying values, or whatever" (p. 61). He believes this is a way to explicitly develop their own critical thinking vis-à-vis their previous positions.

Research was carried out on commitments to climate change teaching declared by teachers of different disciplines. It was observed that, depending on their discipline, these teachers engaged in three types of pedagogical models (positivist, interventionist and critical). These models ranged from educating students in accordance with their

own opinions to teaching students how to make their own choices (Urgelli, Simonneaux, & Le Marec, 2010). In the case of the positivist model, the teachers focused on teaching the reference knowledge of the discipline presented as non-controversial and presumed that this approach would enable the students to make choices as responsible « informed » citizens. In the interventionist model, the teacher intended to question the environmental consequences of human development in relation to the urgency of the climatic issue, or to scientific and technical progress. The declared objective was to stress the need to change behavior and consumption patterns in the face of the rising demand for energy. In the case of the critical model, the teacher declared s/he planned to get the students to take a global view of ways in which expertise on the climate is portrayed in the media—underlining, in particular, that the complexity of the issue is inconsistent with a consensual scaremongering approach by the media to climate-related risks.

The diversity of these engagements can be explained by the ecological convictions and/or epistemological doubts the teacher holds. Epistemological doubt, that is to say the acknowledgement that these questions are controversial and fraught with uncertainties, may be crucial to the way these questions are taught. If the teacher accepts the doubt, he/she may choose a critical approach to the question. Sometimes, in spite of her/his personal doubt, the teacher chooses not to engage students in a critical approach for fear of influencing them on account of his/her institutional position. On the question of climate change, the ecological convictions of the teachers studied by Urgelli (2009) justified an interventionist approach. In the case of issues related to health (gene therapy, the use of embryonic stem cells), we assume that ethical convictions can determine ways with which these questions are dealt.

The nature of the teachers' rationality has an influence on their choice of teaching strategies, depending on whether they adopt a techno-scientific rationality (the techno-sciences will resolve the problems raised by current technosciences) or a critical rationality which implies reflexivity towards the techno-sciences. The teacher's rationality can vary according to the issue.

A study on teachers in agricultural education in France has been conducted. The study focused on SAQs related to animal husbandry (the evolution in meat consumption, the contribution of animal breeding to the greenhouse gas effect, animal welfare). We wanted to discover whether they approached these SAQs on the basis of their ecological or ethical convictions and called breeding practices into question and/or a critical analysis of animal husbandry knowledge. This group tended towards a techno-scientific rationality (Simonneaux, 2012). Faced with these SAQs, the teachers took sides with the breeders above all else. They empathized with the farmers who were angered by the criticism fired against them and by the measures they were required, by law, to take. These teachers believed techno-science would resolve the SAQs. They would like to see more targeted research associated with the development of the techno-sciences in breeding.

The majority of those teachers took a positivist approach to the environmental issues offered up for debate. They assimilated sustainability rhetoric as long as it is associated with productivity. They were confident that techno-scientific progress would resolve the SSIs linked to the environment. But, fundamentally, they minimized the responsibility of animal husbandry and the part it played in the issues

raised (climate change, the food crisis). They were also reticent about the regulations on animal welfare. However, another group of teachers revealed their critical rationality when dealing with the question of pesticides by denouncing the environmental problems and to a lesser extent the problems linking the health of consumers and farmers to pesticide use (Simonneaux & Simonneaux, 2013).

For many authors, such as Agnieszka Jeziorski and Alain Legardez (2013), sustainable development is an SAQ. They have tried to identify what representations future secondary school teachers have of sustainable development and educating for sustainable development, and to analyze the results in terms of what fosters and what hinders a critical education focusing on socially acute questions. Consequently, data were collected using two complementary tools: firstly, a questionnaire was administered on one hand to 223 French Canadian trainee teachers in science and technology and social sciences, and on the other to future teachers of French, Earth and life sciences, history and geography; and, secondly, a semi-directive interview was conducted with 12 respondents to the questionnaire.

From the point of view of socially acute questions, Jeziorski and Legardez consider that ESD is in line with a transformative, participatory approach to education, as referred to by Bob Jickling and Arien Wals (2013). According to them, the position practitioners and academics adopt towards ESD depends on their conceptions of education and the people being educated. They distinguish two conceptions of education: transmissive and transformative. The aim of transmissive education is to unilaterally convey ideas defined by a limited number of external experts. Its goal is efficiency and social reproduction. Transformative education is in complete contrast to transmissive education in that, in the latter, knowledge is co-created within a given context. Thus, the creation of new knowledge is influenced by prior knowledge and different cultural perspectives. The aim is to provide an education for critical citizenship which trains students to question the world in which they live to empower them to create their own world. In general, citizens are educated to conform with a view to social reproduction, that is to say they are trained to accept the role traditionally assigned to them in the work society. In a transformative approach to education, citizens participate in decision-making. Figure 27.1 illustrates the different ways to engage in ESD depending on the representation of education on one hand and the citizens being educated on the other. The vertical axis represents the conceptions of education and the horizontal axis the conceptions of the people being educated. ESD in terms of SAQ would be in quadrant IV.

This research shows that "the positions adopted by the trainee teachers questioned, fluctuate between transmissive education and socio-constructivist transformative education. Both positions may coexist in the same person and come into conflict when it comes to choosing a didactic strategy. The socio-constructivist transformative approach thus limits itself mainly to exposing different points of view (most of the time concerning the implementation of sustainable development, without really discussing it) and providing the students with a context (territorialized education, project-based teaching). The importance of reflexive and interdisciplinary activities and debate on the subject of sustainable development are expressed, but their implementation seems to run counter to the positivist school paradigm of which is still dominant" (p. 31).

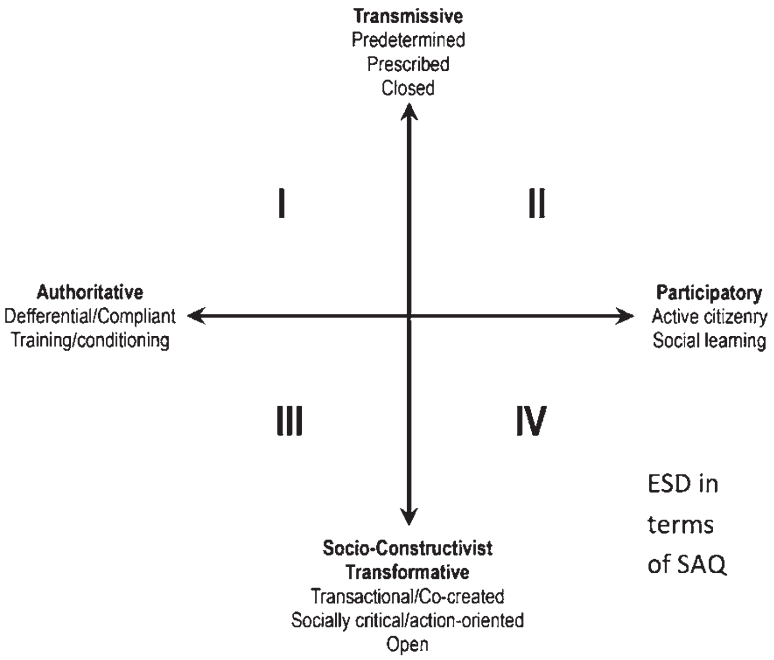

Fig. 27.1 ESD in terms of socially acute questions based on the conception of education and on the conception of the educated person (Adapted by Jeziorski and Legardez from Jickling and Wals, 2013)

The actual work of teachers is not only a personal interpretation of the curriculum prescribed according to the constraints related to the context of the teaching-learning situation. The difference between the task prescribed to teachers and what they actually do can be explained in terms of 'professional genre.' "A collective professional genre retains the transpersonal memory of a work environment. It preserves and transmits social history" (Clot, 2008, p. 77). The results of numerous research projects conducted within the context of 'learning to produce differently' (a program set up by the French Ministry of Agriculture to foster more sustainable forms of production which are more respectful to living organisms and the environment) show that the main obstacle to the so-called agroecological transition is the professional genre to which teachers adhere (Vidal & Simonneaux, 2013). Teachers identify primarily with the professional genre of conventional farmers which is focused on productivity and not with the professional genre of teachers who promote agroecological innovation. They seek legitimacy in the field in order to be accepted by their students who they deem resistant to the agroecological transition, or unaware of the health hazards of pesticide use, for example. We have shown in our research that students are well aware of the issues, but the risk in teaching them as perceived by teachers, leads them to cool down the issues. Jensen and Blok (2008) refer to this as "risk habitus" (p. 765).

27.3.2 From Involvement to Activism via Commitment or Promoting a Sub Political Engagement

This question of commitment and action is becoming increasingly significant to the didactics of SAQ and 'educations for.' It has been apparent in the STEPWISE program for quite some time. The transformative aim is an essential marker but it is necessary to substantiate the possible forms that transformation and change may take within the education system.

For Freire, the activity of teaching has an influence on the world and it cannot be neutral. Freire's perception is set in a specific context (postwar Brazil), where the predominant social challenge is how to tackle poverty in a context of populism and military dictatorship. Logically, emancipation seemed to be the overriding issue and was to lead to protests against injustice in order to let people imagine how to fight against oppression of individuals and communities (Zanchetta, Kolawole-Salami, Perrault, & Leite, 2012). The emancipation of thought remains the factor that allows education to take root in social reality, even if the social challenges are different today (Santos & Mortimer, 2002). In the case of Freire's approach, over and above the steps taken by individuals, it is important to insist upon roles played by the community. Paulo Freire (1972, 1974) affirms that education is a human activity that is inserted in human reality; therefore, its task is to transform the human world. The humanistic education he advocates goes beyond teaching contents without social meanings. It focuses on the human condition and in its transformation. According to Freire, "those that believe that the teacher has to be 'apolitical' are unintentionally and naively supporting the dominant ideology imposed by the technological systems. They reinforce it when they do not discuss it with their students" (Santos & Mortimer, 2002 p. 647). These references to Freire really echo positions of SAQ education and the STEPWISE approach.

We examine here how this educational form targeting commitment to action can actually take shape.

If we consider learning as a process of change and/or empowerment the extent of the changes taking place in the students may be measured in different ways, may be more or less specific and sometimes ambiguous. We first propose to make a distinction between motivation, involvement, commitment, empowerment and activism. We are not claiming that the definitions given here are definitive or that they represent a consensus. Motivation may be seen as the willingness on the part of the students to participate in the educational activity. Understanding instructions, the difficulty of the task, the extent of the challenge or competition and the pleasure factor are all elements which can explain motivation (Simonneaux, Leboucher, & Magne, 2014).

Motivation is certainly a criterion which is conducive to the educational process but does not in any way measure the effectiveness or the extent of the changes occurring in the students.

Involvement may be considered as the students' capacity to become active in the collective training process. The degree of involvement helps us examine the intensity with which the individuals mobilize their attention, their interest and their

enthusiasm in carrying out the learning tasks (Cheffers, Brunelle, & Von Kelsch, 1980). Here, again, the intensity of the involvement, whilst certainly an indicator of the success of the educational process, does not allow us to measure the extent of the changes taking place.

Commitment represents an individual's capacity to take a stance on issues, to undertake action and /or to comply with a more or less pre-determined form of behavior.

Empowerment applies to individuals' ability to make decisions and take control over their lives. Nina Wallerstein and Edward Bernstein (1988) refer to 'individual, social, collective empowerment.'

Activism involves learning about and experiencing participation (Linhares & Reis, 2014), and can go as far as convincing other people to influence the decision makers and to develop actions with a view to improve the well-being of individuals, of societies and of the environment (Bencze, Alsop, & Bowen, 2009). Of course, not everyone agrees with this definition. In a French context, activism may be perceived as a synonym for militancy, sometimes suspected of scaling-up actions without giving them proper thought or may even be associated with violent behavior.

We consider that activism applies to three key elements: awareness, reflexivity and the implementation of actions which are assessed and modified according to what is at stake.

In the case of commitment, empowerment or activism, the indicators correspond to the students' stances regarding what is taught or the educational goals and not simply a form of behavior that is expected in class showing motivation and implication. It is necessary to make this distinction from the outset, but it needs to be developed and clarified. In particular, it raises a methodological problem of observation. There are two ways of interpreting the attitudes of learners who show a predisposition for action, either we look at the components in their language assuming that they will provide an insight into what an individual thinks and that these thoughts determine his behavior, or we base our analysis on directly observable behavior.

Social psychology has identified different action models or theories including the following:

- Involvement is the intensity with which the individuals undertake in terms of attention, interest and enthusiasm in the tasks required by the teachers (Cheffers et al., 1980).
- The theory of planned behavior focuses on an individual's intentions to explain his/her behaviors, which can be understood by his/her attitudes, perceptions of norms, and behavioral controls (Ajzen, 1991).
- Pierre Bourdieu also developed a theory of action around the concept of habitus. This theory seeks to demonstrate that social agents develop strategies based on a small number of *dispositions* acquired through socialization. The identification of these dispositions allows us to determine the potential commitment of individuals to the action.
- The dispositions for action, initially put forward by Bourdieu (1998) are considered by Ria (2012) to be a set of perceptive, interpretative, cognitive, emotional, intentional and actional components mobilized in the same type of situation.

- The commitment theory predicts effects that influence the behavior of another person not by resorting to persuasion but by stimulating a previously minimal behavior which subsequently leads to greater commitment (Kiesler, 1971; Joule & Beauvois, 1987). It is not simply a question of a person being committed or not but rather a question of the extent of the commitment
- Habermas (1987) distinguishes communicative, strategic, normatively-regulated and dramaturgical action. According to him, communicative action presents itself as an interactive activity moving towards agreement and whose function it is to coordinate the actions between participants.
- Neil Mercer (1995) distinguishes the following types of discourse: disputational, cumulative and exploratory talks. The latter are supposedly dominant in collaborative approaches and reveal the collective commitment of the actors.
- The common operational referent is defined as a process shared by a team in order to carry out an action on the basis of each member's skills (De Terssac et Chabaud, 1990).
- A community of practice is a group of people who work together in a situated context. Their objective is to increase their skills in a given practice (Lave & Wenger, 1991) (Table 27.2).

Involvement, individual and collective commitment can be identified through language components (answers to questionnaires and interviews, interactions) and behaviors observable in context.

In Table 27.3, we consider that the minor eco-gestures correspond to the aspects of commitment in the lighter shaded boxes, militancy to the aspects in the grey boxes and finally activism to all the aspects in level 4 in the dark grey boxes.

The 'minor gestures' have often been highlighted in ESD in the form of eco-gestures encouraged by teachers (Jeziorski & Ludwig-Legardez, 2013). However useful they may be, these minor gestures have been called into question by many actors. They do not make it possible to construct and understand a project for society or a community in all its complexity. They may even hinder the understanding of global issues by letting us think that environmental questions can be resolved by these civic eco-gestures. This said, these eco-gestures may, however, be a first step.

A future citizen is not only responsible for his own actions, he must also be able to participate in public decisions, to commit himself to the development of

Table 27.2 Psycho-sociologic models about implication and engagement

Implication	Voluntary accomplishment of learning tasks (Cheffers et al.)
Individual commitment	Theory of planned behavior (Ajzen)
	Dispositions (Bourdieu)
	Theory of commitment (Kiesler), Voluntary submission (Beauvois & Joule)
Collective commitment	Discourses in collaborative practices (Mercer)
	Communicative action (Habermas)
	Common operational referent (De Terssac & Chabaud)
	Community of practice (Lave & Wenger)

Table 27.3 The scope of commitment in educational activities

Criteria for analyzing commitment	Level 1	Level 2	Level 3	Level 4
The intention to act	*Claims an action is relevant*	*Claims that an action should be taken*	*Claims his support for such an action*	*Claims he will commit to such an action*
The individual's role in the action	*Participates occasionally in the action*	*Participates regularly in the action*	*Makes suggestions to assess / improve the action*	*Gets others involved in the action ; is a driving force*
The impact of the action	*A set of minor gestures or individual behaviors*	*Collective assessment of the tasks/gestures*	*Inclusion, assessment of actions in a Long Term plan*	*The action is publicized in the media outside school*
The collective dimension of the action	*Action shared by a group of students*	*Institutionalized action (evaluated) in school*	*Action taken in conjunction with external partners*	*Action taken outside school*
The critical perspective	*Identifies complimentary factors or variations to the action taken*	*Identifies the limits of the action*	*Identifies the controversies and risks*	*Compares the different positions and argues his personal point of view*

a 'sustainable' society and, to do this, he needs to acquire knowledge, values and an ability to live in a community. This conception of the future citizen means we have to define educational goals that are more ambitious than these simple "minor green gestures". The socio-political action which is developed upholds a critical perspective particularly in reference to controversial issues (Linhares & Reis, 2014). It involves fostering commitment AND reflexivity.

Activism is sometimes interpreted as engaging in action without giving it much thought. This is in no way what is meant by the pioneers of the 'activist' movement in schools who have developed a framework called STEPWISE which, as we have already indicated, aims at social and environmental justice and attempts to foster a desire for change and a sense of responsibility among individuals (Bencze, Sperling, & Carter, 2012). These different angles for analyzing and / or fostering action may be seen as a graduation of the goals of educ-actions, ranging from simple adhesion to a project and the development of expected behavior, through adapting behaviors, deciding and reasoning behavioral changes and to societal transformation. Beyond these goals, another focus for the analysis could be the range of actors concerned by these actions. At one end of the scale we may find the student concerned as an individual actor and at the other end this action may concern a wider community outside of school. The degree of autonomy in the learning community, the time-scale (short or long term) and scope (local or global) of the action may constitute other lines of analysis. Over and above these indicators (level

of commitment, the actors concerned, the time-scale and scope) and the extent of the action, we must also examine the purposes and methods used which are pursued according to a given context in all its complexity. This is vital if we are to understand the dynamics involved in an educational project.

27.4 Conclusion: STEPWISE for a Committed Educ-action

The educational perspective of STEPWISE implies interaction between schools and society, between scientific processes and sharing knowledge, between individual and collective processes, between reflexivity and actions ...The socio-political issues and the question of commitment stimulate the sought after critical perspective. STEPWISE promotes the concept of the engaged school and research which contributes to the emergence of critical education. This, to us, seems to be an essential step towards the development of the emancipated eco-citizen. Schools must be transformed in keeping with this critical education. We consider this to be a vital step towards dealing with the challenges facing society today and in the future. This transformative goal for schools may take on different forms: critical education, socio-political education, and activism. We can see huge similarities between the SAQs approach and the STEPWISE program in their aims for scientific, social, political and economic education but there is also a similarity with the humanistic science education sought after by Freire. "The Humanistic Science Education is a slogan that tries to contribute to changing the context of the modern society through educational processes (…) Science Education has a potential to contribute for the transformation of modern society through helping make visible the pitfalls of the system and make people aware of their role as citizen and consumer in this society" (Santos & Mortimer, 2002, p. 641). According to his dialogic action theory, action started in dialogue, word is a transformable praxis, which acts on the world. It supposes a collective action in which subjects meet in cooperation to transform the world. Wildson Santos and Eduardo Mortimer add a humanistic argument to STS education. "This argument brings to discussion to the need of transforming scientific and technological modern society through human values, preparing the students for a society in which sustainable knowledge and responsible action are the norms. This is not a movement anti-technology, but a movement against a particular model of economic development and technological practice" (p. 646). The inclusion of SSI or SAQ in education is necessary but it must integrate not only science contents but also "the understanding of environmental risks; the power of domination that the technological system impinges in culture; the difference between human needs and market needs; and the developing of attitudes and values consistent with a sustainable development" (p. 647).

Yves Chevallard (2010, 2014) a pioneer in the didactics of mathematics in France, who developed the concept of didactic transposition, challenges, in his later writings, what he calls the paradigm of visiting Works; that is to say, a form of schooling based on the transmission of knowledge that is disconnected from the issues that led to its

production. This is what he refers to as the *old school paradigm* which aims to create differences, to select an elite by venerating knowledge presented in a monumentalist, frontal fashion with an authoritarian relationship to truth (the teacher proclaims). He contrasts this with *the paradigm of questioning the world;* that is to say, the pedagogy of inquiry for a democratic school which creates citizenship where knowledge is alive and is an instrument for improving community life and taking control of the world. He considers that the didactitian should not withdraw into his/her discipline but should become "gyrovague" [2]; in our opinion, this means he should be open to interdisciplinarity and the integration of lay-knowledge.

In the European project PARRISE (Promoting Attainment of Responsible Research and Innovation in Science Education) within the framework of the 7th European Science and Society program in which several authors of the present chapter participated, an investigative approach to SSI is modelled « SocioScientific Inquiry Based Learning » (SSIBL)[3]. This approach should lead students to set up actions. It remains to be seen whether these actions will be 'cooled down' or 'heated up' from an activist point of view.

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[2] The word *gyrovague*, (from Late Latin *gyrovagus*, from Latin *gyro-* gyr- + *vagus* wandering) originally refers to a wandering and usually dissolute monk of the early church. Chevallard, 2014, p. 40.

[3] Also see Chap. 22, this volume, for more information about the SSIBL framework.

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