# Mode 2

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## Definition

The Latin word *modus* is often translated simply as "manner". It originally meant "measure, weight", but is also etymologically related to the diminutive *modulus*, meaning "scale, small measure" and "model" (Müller 2009, 638). There is little evidence in the research literature on Mode 2 that the word describes a model of science. Such an interpretation is obvious, because the differences between the two modes of science, which are the starting point of the discussion, can be understood primarily in terms of ideal types (Nowotny 1993, 70; Schauz 2014, 49): Mode 2, for example, stands for forms of knowledge creation that take place under the influence of industrial technology developments, and public- and private-sector organizations and state institutions involved in them, and bear the character of application-oriented, practice-integrated, and cross-disciplinary research. Consequently, the scientific aspiration to overcome contradictions in knowledge recedes into the background while practical solutions come to the fore. Mode 2 stops when a practical solution is found and implemented.

Mode 2 indicates the historical development of knowledge societies, whose knowledge – according to Max Weber (1934) – is distinguished from impartial, value-, and contradiction-free knowledge and rather finds recognition through its robustness and functionality in transformation processes. Mode 1, on the other hand, is regarded as the product of basic research, which can also refrain from practical solutions and decisions within the protected framework of universities and research institutions.

The two modes thus become ideal-types, distinguishable as models of science. Regardless of whether ideals (such as that of unbiased and contradiction-free knowledge) have actually been fulfilled, they become for Mode 1 one of its essential characteristics. Furthermore, it is said that Mode 1 and 2 do indeed coexist and interact in real terms (Gibbons et al. 1994, 9). What belongs to this or that mode is to be distinguished analytically.

Mode 2 does not follow rigorously the ideal of science to generate universal knowledge. It accepts value-based judgments and contradictions; heterogeneity, utility orientation, commercialization, dialogicity and reflexivity, transdisciplinarity, and fluctuating forms of collaboration are seen as aspects of the Mode 2 knowledge production (Gibbons et al. 1994, 3–8). For higher education that addresses, for example, problem-based learning in real-world laboratories, through service learning or citizen science, the decrease in rigorousness raises fundamental questions of transdisciplinary learning.

## Background

The distinction of two modes of knowledge creation sparked an international discussion, particularly in the fields of science and technology studies, technology assessment, philosophy of science, and management (Bartunek 2011; Etzkowitz and Leydesdorff 2000; Nowotny 1999; Nowotny et al. 2001, 2003). It also inspired analyses of the transdisciplinarity of research practices, such as those found in the marketplace of digital information goods and services and other areas of high complexity (Holtgrewe 2012; Klein et al. 2001; Weingart 1997). Furthermore, forms of participation in practice-oriented research and their importance for gaining knowledge have been discussed (Jahn et al. 2012).

Several assumptions and views of the Mode-2 approach were already widespread in sociology and science studies (Bender 2001, 9; Jasanoff 2003; Nowotny 1993) when the approach was launched. Long before the 1990s, the "unity of the sciences" (*Einheitswissenschaft* as Neurath, Carnap and others termed it in the 1930s) was already doubted. At the beginning of the 20th century, representatives of the neo-positivist Vienna Circle such as Carnap (1931, 465) still defended the basic idea that the conflict between disciplines could be overcome and that true knowledge could be unified. In the 1950s, van Orman Quine's (1951) thesis of "two dogmas" and Snow's (1959) thesis of "two cultures" sought to describe the fact that certain subjects were sufficiently akin, so that scientists from similar disciplines would be able to communicate, while an unbridgeable gap had formed in relation to other disciplines. In this way, they primarily underpinned the difference between the humanities and the natural sciences. Research on "knowledge (science) cultures" (Arnold and Fischer 2004; Nerland 2012), sometimes with reference to Fleck's (1980) "thought collectives", sometimes to Kuhn's (1962) "paradigms". Also Polanyi's (1962) theory on the tacit dimension, among others, assumed an increasing differentiation of the sciences. The argument against a positivist notion of a unified science was that all knowledge is socially constructed (Knorr Cetina 1991, 2002). Disciplines create "life", e.g. in laboratories incorporating various "phenomenotechniques" (Bachelard 1998) and socially establish orders which form the rational background of scientific practices (Latour and Woolgar 1979). This epistemic argument did not express a new unification thesis (*science as one*) against the diversification of disciplines. Rather, the blaming of every kind of social influence that would contaminate scientific research was contested. Latour and Woolgar (1979, 23–24) concluded that the influence of the social on the scientific endeavor is not only visible in errors: "Scientific achievements held to be correct should be just as amenable to sociological analysis as those thought to be wrong". Knorr Cetina (1999, 4) similarly refuted the idea of a unified science or "one enterprise" of science in favor of analyzing a "whole landscape – or market – of independent epistemic monopolies producing vastly different products". From an epistemological rather than a sociological point of view, Rheinberger (2005, 316) resumed Bachelard's conclusion that "with the ever tighter interplay between ever more specific forms of knowledge and the phenomenal world, the sciences necessarily become fragmented into different epistemological regions" and "their conceptual dynamics finally became inseparable from the phenomena in which and through which they expressed themselves".

Since the 1970s, the concept of the transdisciplinarity of research (Bernstein 2015; Scholz 2020) has replaced a possible integration of all bodies of knowledge into one science and increasingly referred to a spillover of scientific efforts to many areas of society (Jahn et al. 2012). At the same time, while examining the socio-cultural dependency of thinking and knowledge creation, a practice-philosophical turn was also proclaimed – the *practice turn* (Schatzki et al. 2000), which borrowed from Marx the overcoming of the subject–object dualism, without understanding the turn itself as a Marxist one. Marx's first Feuerbach thesis – written in 1845, intended only for his eyes, not for the public – phrased the essential point in a nutshell: "The chief defect of all hitherto existing materialism – that of Feuerbach included – is that the thing, reality, sensuousness is conceived only in the form of the *object* or *of contemplation*, but not *as sensuous human activity, practice,* not subjectively" (Marx 1995; italics in the original). This thesis thus already contained the radical demand to place the epistemic subject back into the practical context – where it sometimes does not even approximately possess an all-encompassing and disinterested gaze, but must immanently reflect on its particular relationship to the object of knowledge (including the method and means of research), i.e. how the things became objects of knowledge, how they adopted the *form* of an object (Marx 1996). Thus, objects are seen as something changeable, something that can adopt different forms and therefore need to be interpreted in the practical contexts. The unity of recognition and change thus became the key to a new epistemology.

The practice-philosophical paradigm shift took place in various currents in the 20th century: for example, with feminist philosophy of science (Haraway 1988; Harding 1986), laboratory studies in the context of science and technology research (Knorr Cetina 1991; Rip 1997), historical epistemology (Rheinberger 1994), and sociological approaches (Bourdieu 1979). It involved understanding science and theory not as the opposite of practice, but as *doing science* and uncovering its power relations and hidden mechanisms. Further approaches emphasized, similar to Berger and Luckmann's (1966) social constructivist or Alfred Schütz's (1971) phenomenological conception of "everyday knowledge", that knowledge becomes effective in local contexts of practice. In the 1980s, studies emerged which explored how knowledge is distributed – and at least partly shared – among people as members of a community and thus must be understood as situated knowledge (Lave and Wenger 1991; Suchman 1987).

Since science creates communities with different cultures and contexts of research, scientific knowledge too is then regarded as situated knowledge. Thus, these currents were also concerned with the insight that science should not be considered as an institution somehow outside of society and completely independent of it. The postulate of impartiality was rejected as an insufficiently reflected idealization of scientific knowledge (Haug 2004). Scientific knowledge always articulates a standpoint and a perspective (Haug 2004).

The Mode-2 approach added to the practice-philosophical paradigm shift in the social sciences that there was a historically new way of producing knowledge in all areas of society through a stronger interconnection of segments such as industry, politics, and research, which would no longer be institutionalized in the conventional pattern of science in universities and similar research institutions (Gibbons et al. 1994, 10). With respect to technological development, the theses of the Mode-2 approach partly overlap with those of Machlup (1962), Drucker (1969), or Bell (1973), who emphasized the increasing influence of science on (industrial) production and political society (Hack 2001, 25), thus also addressing the transformation of the "scientification of society" into a "politicization of science" (Weingart 1983, 235) as a problem. Interpreted as a loss of power or as a phenomenon of dissolution, there is also a warning of the danger of the "de-professionalization" (Weingart 1983, 235) of scientific expertise.

The views that Gibbons et al. put forward touch on and flank theses from the currents that were outlined in the previous sections. The affirmed tendencies of a politicization and an economization of science are subsumed under the term 'Mode 2'. The authors' specific concern is to present a heuristic assumption that can be used to elaborate historical changes in the social role of science (Gibbons et al. 1994, 1).

However, since the boundary between modes runs between ideal-typical opposites, the diagnosis is not developed empirically, not in a historical-critical way. Its soundness has therefore become the subject of a debate (Birrer 2001; Gläser 2001). This is particularly evident in claims that Mode 1 still harbors an "epistemic core of the sciences", while science in Mode 2 exists ubiquitously, rhizome-like, without center and goal and without inner and outer boundaries (Nowotny 1999, 30–31, 118), alluding to a metaphor used by Deleuze and Guattari (1987). Consequently, whether a Mode 2 has actually emerged depends on the question of whether a Mode 1 existed at all.

From the perspective of Gibbons et al. (1994), however, it is helpful not to take Mode 1 as the only mode of science for breaking down narrowed notions. A central argument here is that the transdisciplinary and more participatory forms of research practice create a different pattern and thus different rules of institutionalization. Processes of institutionalization are important for the creation of scientific knowledge to be societally relevant (Langemeyer 2021). Mode 1 can be understood not only as a way of being, but at the same time as a "necessary myth" (Nowotny 1999, 81), a "symbolic resource" (44), that ensures the public's lack of trust in scientific reason. By relying on context-independent knowledge and – as the Vienna Circle historically did – on the unity of the sciences, Mode 1 could sufficiently legitimize the generated knowledge of science and give it social authority and power (Drori et al. 2006; Nowotny 1999, 22). According to another assessment – Nowotny (1999, 115) also sees this – the changes of the institution of science reveals the deeper problem of "democratic participation" in and through science. Since scientification runs deep into the fabric of Western societies (into its culture, see Drori et al. 2006) with their ideal of democracy and scientific progress, a caricature of science emerges: Mode 1 serves only as the foreshadowing of knowledge with social authority, whereas the critical reflection of knowledge shifts to ideas vaguely connected to Mode 2 – but the rigorousness of Mode 1 is gone. The construction of opposite modes ends in a deadlock.

## Debate and criticism

The sociologically understood distinction between two modes of knowledge production ignited science-theoretical debates of the late 20th century. The debates revolve around a historical transformation of science. The mere obsolescence of ideas, theories, methods, and paradigms is not meant here, but rather the specific pressure for change, which affects science and brings it into closer interdependence with economic, political, and other societal actors who profit from research or scientific standards and norms and thus establish power relations.

Bora (2005, 755–56) highlights that Nowotny et al. grasp the emergence of "open systems" of knowledge production – which raises the question whether the notion of a "closed system" could ever apply to science. According to Frederichs (2001, 73), the Mode-2-approach touches on the setting: Knowledge is created where problems arise and are to be solved. This in turn provokes the question whether all problems are scientific problems, and whether solutions naturally reveal the scientific explanation of why something works.

From an epistemological point of view, science is not accomplished by registering and stating what "there is" just because something seems evident. It is not realized by merely solving problems. Scientists rather need to critically reflect on how they interpret a particular phenomenon, how they distinguish its components or the different states of its development, how they construct and identify the underlying causal or systemic relations, and how they find empirical evidence for this. They need to develop an argument for why that data is relevant, valid, and usable for the research object, and why this object is adequately scrutinized by a certain research method. In practice, when people solve problems, for example, there are limits and obstacles for ensuring that these reflections together with the coordination between theoretical and empirical steps are undertaken with rigor. Therefore, Hack (2001, 55) also criticizes that adherents of the Mode-2 diagnosis erroneously assume that "traditional" scientific knowledge (which they term Mode 1) would emerge without this kind of reflection. He alleges that in their point of view, Mode 1 would already be deprived of everything that constitutes the distinctive features of scientific knowledge: as a form of reflection and as way of retracting and restarting trains of thought that have been shown to be flawed.

Carayannis and Campbell (2012, 4) also see a deficit of reflection in Mode 2. However, without defining the necessities of reflection, they advocate a model of "knowledge production systems" – "Mode 3". "Mode 3" indicates higher-order learning processes and thus means a somewhat higher reflexivity and reflectiveness in change and innovation processes. In doing so, they ignore the fact that science is always based on reflexivity – even in Mode 1. An imagined increase in reflexivity from Mode 1 to Mode 3 creates the fiction of a success story. Hence, Hack's critique of a truncated understanding of science is also applicable to Carayannis and Campbell.

And there is another issue: With Mode 3, as with other innovation paradigms, the argument was made that "models of science" could be deliberately chosen to foster, for example, sustainable development (Liyanage and Netswera 2022, 1128). Regardless of what goals should be achieved (sustainability, innovation, etc.), reflexivity is not a quantitative, but a qualitative matter. It does not make sense to speak of an increased reflexivity without identifying why reflections in the concrete research processes are needed and in what ways.

In contradistinction, if models of science were only a matter of choice (like choosing an instrument or a technique), the distinction between the different paradigms *emerging from* research in different disciplines and the overall concept of science is blurred. Consequently, it seems possible to merely create and change definitions of science deliberately beforehand *without reflecting* on developments of disciplines from within. Ironically, this would be a loss of reflexivity.

Furthermore, the practices of knowledge described by Mode 2 raise the questions of which power relations emerge with them and how existing ones are changed by the fact that other institutions and actors are involved in knowledge production than the traditional ones (such as universities and research institutions which are legally protected to sustain their independence). Similarly, the different forms of knowledge, which arise partly from scientific disciplines and partly from professional, political, and economic expertise, can be addressed as a problem. How they come together in a transdisciplinary way so that a new form of scientific knowledge (expertise) and not just a kaleidoscopic assemblage of different elements emerges has not been clarified. A few works deal with the problem of how this might be accomplished through intellectual cooperation (Jahn et al. 2012: 5; Langemeyer 2015). Nevertheless, it can be assumed that the less planned and more unstructured forms of collaboration depend on new ways of working and expertise becoming institutionalized at some point. The efficacy gained from this is particularly relevant for long-term project goals such as the energy transition or climate protection. How this institutionalization could meaningfully take place may be a central task of research on transdisciplinary didactics in the future, in the context of which dealing with societal complexity and unsolved problems is examined as a form of learning.

## Current forms of implementation in higher education

So far, only partial implementations of knowledge creation in Mode 2 are known in the field of innovations in higher education didactics, for example in approaches of service learning, citizen science, or in forms of research-based or problem-based learning. However, a systematic introduction of such Mode 2 elements into an entire study program would hardly be conceivable without a balancing act between traditional and novel ideals and orientations (Balsiger 2015). However, if universities and colleges, in their function as knowledge institutions that develop and pass on academic knowledge, were to act more as "change agents" (Scholz 2020) in the future, there would have to be a fundamental agreement on the following aspects of transdisciplinary learning.

Nine aspects should be taken into consideration: (1) If knowledge is no longer measured by the ideal of an impartial or value-free form of science without contradictions, how can *values relevant to practice* be meaningfully addressed in concrete content and qualification goals of a degree program? What normative viewpoints should transdisciplinary teaching be about, and how can students critically engage with competing values of practice?

What transformational knowledge can be anchored and taught in (2) *degree programs* in a planned and lasting way? To what extent can the curriculum address real-world problems that spring from different conjunctures? At what point does it become arbitrary and lose its effectiveness?

Can real-world problems, their respective context, and their (possible) solution processes be taken up in the framework of (3) a *curriculum* in such a way that teaching and learning, and the necessary reflections of students and teachers on the subject matter, take place meaningfully? How often can and must learning processes go through a cyclical structure of (4) *iterating actions and reflections* to achieve a meaningful learning outcome or acquisition of skills? How do students acquire the ability to overcome barriers and boundaries created by different (5) *professional languages* and cultures? To what extent can students protect themselves from capture by (6) *stakeholder interests* in the field? How can they be protected? Is academic (7) *socialization* made more difficult by the fact that students are involved in practice-oriented research projects? How can consciousness be raised about (8) *professional cultures* and their limits? How can the distance between the academic world and everyday contexts be established in such a way that learning does not come under increasing pressure to make premature or even (9) *erroneous conclusions*?

These questions point to a profound process of change in academic conceptions of education, insofar as transdisciplinarity becomes more prominent for learning processes. To be sure, some voices will continue to warn of disintegration and threats to academia – and their arguments will be cogent, like those of critics of the Mode 2 diagnosis. Nevertheless, the opportunities that become attainable with the transformations of learning should also become apparent. For scientific research is, at its best, transformative learning, whose participants not only find solutions, but also learn to consciously shape research and knowledge processes, which ultimately contribute to the democratization of the sciences.

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