Handboek natuurkundedidactiek | hoofdstuk 1: Natuurkunde

**1.2 Aard van natuurwetenschap**

**Cursusactiviteit**

***Nature of Science* profiel**

**1** **Oriënteren**

Hieronder staat het artikel *Your nature of science profile: An activity for science teachers* (Nott & Wellington, 1993).

1. Lees de inleiding van het artikel, voer de activiteit uit en stel daarbij je eigen *nature of science profile* op. Lees daarna de rest van het artikel.

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| **Your nature of science profile: An activity for science teachers**  Mick Nott and Jerry Wellington  **Introduction**  The ‘nature of scientific ideas’ is identified in de general introduction to the programmes of the study of the Science National Curriculum as one of the ‘essential elements of a developing experience of science’ [1]. The way that teachers teach science may be linked to the science teacher’s understanding of science. We think that teachers of science should be prepared to articulate their own understandings of the subject they teach.  The aim of this activity is to encourage teachers to critically consider the image that they have of science. We feel that this image is an important one for people to explore because it may have profound implications for the way teachers present and teach science in the classroom. The activity which follows should be treated as a way of getting teachers to think, learn and reflect rather than as a valid measurement of their position on some sort of objective scale. Teachers need not worry if, at the end of the activity, their profile of science is not as expected. The thing to do then is to consider why – this is part of the process.  This activity is based on a similar activity designed to get teachers reflect on their views of process versus content in science education, and separate sciences versus an integrated approach [2].  **Activity**  Please read each of the statements carefully. Give each one a number ranging from “strongly agree” (+5) to “strongly disagree” (– 5) and place it next to the statement. A score of 0 will indicate a balanced view (for the moment, ignore the initials in brackets). | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | **Statement** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | **Score** | |
| 1 | The results that pupils get from their experiments are as valid as anybody else’s. (RP) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 2 | Science is essentially a masculine construct. (CD) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 3 | Science facts are what scientists agree that they are. (CD, RP) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 4 | The object of scientific activity is to reveal reality (IR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 5 | Scientists have no idea of the outcome of an experiment before they do it. (ID) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 6 | Scientific research is economically and politically determined. (CD) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 7 | Science education should be more about the learning of scientific processes than the learning of scientific facts. (PC) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 8 | The processes of science are divorced from moral and ethical considerations. (CD) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 9 | The most valuable part of a scientific education is what remains after the facts have been forgotten. (PC) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 10 | Scientific theories are valid if they work. (IR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 11 | Science proceeds by drawing generalizable conclusions (which later become theories) from available data. (ID) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 12 | There is such a thing as a true scientific theory. (RP, IR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 13 | Human emotion plays no part in the creation of scientific knowledge. (CD) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 14 | Scientific theories describe a real external world which is independent of human perception. (RP, IR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 15 | A good solid grounding in basic scientific facts and inherited scientific knowledge is essential before young scientists can go on to make discoveries of their own. (PC) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 16 | Scientific theories have changed over time simply because experimental techniques have improved. (RP, CD) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 17 | “Scientific method” is transferable from one scientific investigation to another. (PC) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 18 | In practice, choices between competing theories are made purely on the basis of experimental results. (CD, RP) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 19 | Scientific theories are as much a result of imagination and intuition as inference from experimental results. (ID) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 20 | Scientific knowledge is different from other kinds of knowledge in that it has higher status. (RP) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 21 | There are certain physical events in the universe which science can never explain. (RP, IR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 22 | Scientific knowledge is morally neutral – only the application of the knowledge is ethically determined. (CD) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 23 | All scientific experiments and observations are determined by existing theories. (ID) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| 24 | Science is essentially characterized by the methods and processes it uses. (PC) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | \_\_\_\_\_ | |
| **Nature of science profile**  You can use your responses, using our scoring system, to work out a profile of your nature of science.  Put your score for each statement in the appropriate box(es) (some statements “score” twice!). Some “scores” have to have their sign reversed (ie multiply by (–1)) before they can be used. This is indicated by a “–“ next to the number, eg, if your response to statement 1 is –3, then the score in the right-hand column on the RP boxes will be +3.  Add up the scores in the right-hand columns to give you a grand total for each grid. Transfer these grand totals from the columns to the position on each relevant axis. Join up the five marks. This is your profile at this moment. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **RP** | |  | | |  | | |  | | | **ID** | | |  | | |  | | | |  | | **CD** | | | |  |  | | | |  | | **PC** | | | |  | | |  | | |  | | | **IR** | | |  | | |  |
| statement | | | | | score | | |  | | | statement | | | | | | score | | | |  | | statement | | | | | score | | | |  | | statement | | | | | | | score | | |  | | | statement | | | | | | score |
| 1 | | – | | | \_\_\_ | | |  | | | 5 | | | – | | | \_\_\_ | | | |  | | 2 | | | | – | \_\_\_ | | | |  | | 7 | | | | – | | | \_\_\_ | | |  | | | 10 | | | – | | | \_\_\_ |
| 3 | | – | | | \_\_\_ | | |  | | | 11 | | | – | | | \_\_\_ | | | |  | | 3 | | | | – | \_\_\_ | | | |  | | 9 | | | | – | | | \_\_\_ | | |  | | | 21 | | | + | | | \_\_\_ |
| 21 | | – | | | \_\_\_ | | |  | | | 19 | | | + | | | \_\_\_ | | | |  | | 6 | | | | – | \_\_\_ | | | |  | | 17 | | | | – | | | \_\_\_ | | |  | | | 4 | | | + | | | \_\_\_ |
| 12 | | + | | | \_\_\_ | | |  | | | 23 | | | + | | | \_\_\_ | | | |  | | 8 | | | | – | \_\_\_ | | | |  | | 24 | | | | – | | | \_\_\_ | | |  | | | 12 | | | + | | | \_\_\_ |
| 14 | | + | | | \_\_\_ | | |  | | | total | | | | | | \_\_\_ | | | |  | | 13 | | | | + | \_\_\_ | | | |  | | 15 | | | | + | | | \_\_\_ | | |  | | | 14 | | | + | | | \_\_\_ |
| 16 | | + | | | \_\_\_ | | |  | | |  | | |  | | |  | | | |  | | 16 | | | | + | \_\_\_ | | | |  | | total | | | | | | | \_\_\_ | | |  | | | Total | | | | | | \_\_\_ |
| 18 | | + | | | \_\_\_ | | |  | | |  | | |  | | |  | | | |  | | 18 | | | | + | \_\_\_ | | | |  | |  | | | |  | | |  | | |  | | |  | | |  | | |  |
| 20 | | + | | | \_\_\_ | | |  | | |  | | |  | | |  | | | |  | | 22 | | | | + | \_\_\_ | | | |  | |  | | | |  | | |  | | |  | | |  | | |  | | |  |
| total | | | | | \_\_\_ | | |  | | |  | | |  | | |  | | | |  | | total | | | | | \_\_\_ | | | |  | |  | | | |  | | |  | | |  | | |  | | |  | | |  |
| **Relativism Positivism** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| -40  | | | | -35  | | | | | -30  | | | -25  | | | | | -20  | | | | -15  | | | | -10  | | | | -5  | | | | | RP  | | | | 5  | | | | | 10  | | | | 15  | | | | 20  | | | | 25  | | | | | 30  | | | 35  | | | | | 40  | | |
| **Inductivism Deductivism** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| -20  | | | | | | | -15  | | | | | | | -10  | | | | | | | -5  | | | | | | | ID  | | | | | | | | 5  | | | | | | | 10  | | | | | | | 15  | | | | | | | 20  | | | | | |
| **Contextualism Decontextualism** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| -40  | | | | -35  | | | | | -30  | | | -25  | | | | | -20  | | | | -15  | | | | -10  | | | | -5  | | | | | CD  | | | | 5  | | | | | 10  | | | | 15  | | | | 20  | | | | 25  | | | | | 30  | | | 35  | | | | | 40  | | |
| **Process Content** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| -25  | | | | | -20  | | | | | | | -15  | | | | | | -10  | | | | | | -5  | | | | | | PC  | | | | | | 5  | | | | | | 10  | | | | | | 15  | | | | | | 20  | | | | | | | 25  | | | |
| **Instrumentalism Realism** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| -25  | | | | | -20  | | | | | | | -15  | | | | | | -10  | | | | | | -5  | | | | | | IR  | | | | | | 5  | | | | | | 10  | | | | | | 15  | | | | | | 20  | | | | | | | 25  | | | |
| **What’s your nature of science?**  Having done all this then what does it mean? Many of the terms used may be unfamiliar.  In fact, many of these words are problematic and a matter of debate. Their meaning change and shift and can be seen as insults or praise depending on to whom you are talking.  We offer below our definitions for the meanings attached to the five continua above. In doing this we have consulted Bynum et al. [3], Wellington [4] and Ziman [5].  **Relativism/Positivism**  Relativism – You deny that things are true or false solely based on an independent reality. The ‘truth’ of a theory will depend on the norms and rationality of the social group considering it as well as the experimental techniques used to test it. Judgements as to the truth of scientific theories will vary from individual to individual and from one culture to another, ie truth is relative, not absolute.  Positivism – You believe strongly that scientific knowledge is more ‘valid’ than other forms of knowledge. The laws and theories generated by experiments are our descriptions of patterns we see in a real, external objective world.  To the positivist, science is the primary source of truth. Positivism recognizes empirical facts and observable phenomena as the raw material of science. The scientist’s job is to establish the objective relationships between the laws governing the facts and observables. Positivism rejects inquiry into underlying causes and ultimate origins.  **Inductivism/Deductivism**  Inductivism – You believe that the scientist’s job is the interrogation of Nature. By observing many particular instances, one is able to infer from the particular to the general and then determine the underlying laws and theories.  According to inductivism, scientists generalize from a set of observations to a universal law ‘inductively’. Scientific knowledge is built by induction from a secure set of observations.  Deductivism – In our definition this means that you believe that scientists proceed by testing ideas produced by the logical consequences of current theories or of their bold imaginative ideas.  According to deductivism (or hypothetico-deductivism) scientific reasoning consists of the forming of hypotheses which are not established by the empirical data but may be suggested by them. Science then proceeds by testing the observable consequences of these hypotheses, ie observations are directed or led by hypotheses – they are theory laden.  **Contextualism/Decontextualism**  Contextualism – You hold the view that the truth of scientific knowledge and processes is interdependent with the culture in which the scientists live and in which it takes place.  Decontextualism – You hold the view that scientific knowledge is independent of its cultural location and sociological structure.  **Process/Content**  Process – You see science as a characteristic set of identifiable methods/processes. The learning of these is the essential part of science education.  Content – You think that science is characterized by the facts and ideas it has and that the essential part of science education is the acquisition and mastery of this ‘body of knowledge’.  **Instrumentalism/Realism**  Instrumentalism – You believe that scientific theories and ideas are fine if they work, that is they allow correct predictions to be made. They are instruments which we can use but they say nothing about an independent reality or their own truth.  Realism – You believe that scientific theories are statements about a world that exists in space and time independent of the scientist’s perceptions. Correct theories describe things which are really there, independent of the scientists, eg atoms.  **Points for discussion**  We believe that you can produce a ‘profile’ of your views of the Nature of Science. This can be done by drawing a line joining up your position on each axis. Try it.  Having had a chance to read our working definitions of our meanings, then consider the points below:  ● How do you feel about your profile? Has it really ‘measured’ your views about science?  ● Do you feel confident that you understand it all?  ● Do you think your views/opinions have been challenged or changed by the exercise? Would you like to go back now and do it again?  ● Would you like to try it out on your colleagues?  Whatever the shape of your profile, then please do not worry and do not panic! There are many ‘natures of science’.  **Concluding remarks**  We have borrowed heavily from other work done in this area [7,8]. The first of these works interestingly suggests that teachers’ understandings of the Nature of Science are not rigid or fixed. This may not be surprising as this also appears to be true for scientists too! [9]. The second reference is an analysis of teachers’ constructs of science and appears to indicate that the small sample used were, crudely speaking, positivist and decontextualist. Many of the issues raised in this report indicated the type of statements we should write for the profile to test the above finding.  We have tried this activity with a number of individuals and groups of teachers, student teachers, and lecturers in Higher Education. The main aim of the activity, as we mentioned in the introduction, is to encourage people to reflect upon their own view of science. Our trial sessions indicate that it *does* succeed in doing this. We feel that this is a valuable activity because there is some evidence that teachers’ views of science act as one of the many influences on the way they structure and present the science curriculum [10].  We emphasize, however, that it does *not* purport to be a ‘valid measurement’ of an individual’s position or ‘philosophy’.  We hope that people enjoy doing this activity and we welcome feedback on any part of it, however small or detailed.  **References**  1 DES, *Science in the National Curriculum*, (HMSO, 1991).  2 Wellington, J, 1988, ‘Balanced science: where do you stand?’, *SSR*, 1988, **70**(251), 145-7.  3 Bynum, WF, EJ Browne and R Porter, *Macmillan Dictionary of the History of Science*, (Macmillan, 1983).  4 Wellington, J (ed), *Skills and Processes in Science Education: a Critical Analysis*, (Routledge, 1989).  5 Ziman, J, *Teaching and Learning about Science and Society*, (Cambridge University Press, 1980).  6 Ziman, J, *An Introduction to Science Studies*, (Cambridge University Press, 1984).  7 Kouladis, V and J Ogborn, ‘Philosophy of science: an empirical study of teachers’views’, *Int J Sci Ed*, 1989, **11**, 2, 173-84.  8 Lakin, S and J Wellington, ‘Teaching the nature of science: a study of teachers’ views of science and their implications for science education’, (Division of Education, University of Sheffield, 1991).  9 Mulkay, M and N Gilbert, 1984, ‘Theory choice’, included in Mulkay, M, *The Sociology of Science*, (Open University Press, 1991).  10 Lederman, N, ‘Students’ and teachers’ conceptions of the Nature of Science: a review of the research’, *J Res Sc Tea*, 1992, **29**(4), 331-59. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

1. Geef een korte karakteristiek van je eigen *nature of science profile* met behulp van de in het artikel gegeven toelichting op de vijf schalen.
2. Bereid een discussie voor over je eigen *nature of science profile* en die van de anderen in de groep, bijvoorbeeld aan de hand van de in het artikel genoemde vier *points for discussion*.

**2** **Evalueren**

Lees en bespreek paragraaf 1.2 van het handbook, al dan niet in combinatie met het hoofdstuk *The principal elements of the nature of science: Dispelling the myths* (McComas, 1998) en het artikel *What “ideas-about-science” should be taught in school science? A Delphi study of the expert community* (Osborne et al, 2003).

1. Stel na de bespreking opnieuw je eigen *nature of science profile* op. Welke verschuivingen zijn er in je profiel opgetreden?
2. Analyseer globaal het leerboek dat op je (stage)school voor natuurkunde in gebruik is op het beeld van de *nature of science* dat deze methode aan de leerlingen overbrengt.

**Opmerking**

Het antwoord op de vraag wat nu ‘de’ *nature of science* is, zou iets kunnen zijn als: “*There is no singularly preferred or informed nature of science – the nature of science is as tentative, if not more so, than scien­tific knowledge itself.*” (Lederman, 1992).

**Literatuur**

Lederman, N.G. (1992). Students’ and teachers’ conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching 29*(4), 331-359.

McComas, W.F. (1998). The principle elements of the nature of science: Dispelling the myths. In W.F. McComas (Ed.), *The Nature of Science in Science Education: Rationales and Strategies* (pp. 53-70). Dordrecht: Kluwer.

Nott, M. & Wellington, J. (1993). Your nature of science profile: An activity for science teachers. *School Science Review 75*(270), 109-112.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R. & Duschl, R. (2003), What “ideas-about-science” should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching 40*(7), 692-720.