



# **Developing evaluation competence in order to strengthen the ability to form an independent opinion**

Prof. Dr. Ingo Eilks FRSC, SUSTAIN Final Conference 2016

# Evaluation competence – What do we mean?



<http://www.sinus-hessen.de/bilsta/>

# Evaluation competence in the German SE standards

		Anforderungsbereich		
		I	II	III
Kompetenzbereich	Fachwissen	Kenntnisse und Konzepte zielgerichtet wiedergeben	Kenntnisse und Konzepte auswählen und anwenden	komplexere Fragestellungen auf der Grundlage von Kenntnissen und Konzepten planmäßig und konstruktiv bearbeiten
	Erkenntnisgewinnung	Bekannte Untersuchungsmethoden und Modelle beschreiben, Untersuchungen nach Anleitung durchführen	geeignete Untersuchungsmethoden und Modelle zur Bearbeitung überschaubarer Sachverhalte auswählen und anwenden	geeignete Untersuchungsmethoden und Modelle zur Bearbeitung unbekannter Sachverhalte begründet auswählen und anpassen
	Kommunikation	bekannte Informationen in verschiedenen fachlich relevanten Darstellungsformen erfassen und wiedergeben	Informationen erfassen und in geeigneten Darstellungsformen situations- und adressatengerecht veranschaulichen	Informationen auswerten, reflektieren und für eigene Argumentationen nutzen
	Bewertung	vorgegebene Argumente zur Bewertung eines Sachverhaltes erkennen und wiedergeben	geeignete Argumente zur Bewertung eines Sachverhaltes auswählen und nutzen	Argumente zur Bewertung eines Sachverhaltes aus verschiedenen Perspektiven abwägen und Entscheidungsprozesse reflektieren

To weigh arguments for the evaluation of an issue from different perspectives and to reflect processes of decision making.

(KMK-Standards, 2004)



## An excursus

- There is a wide agreement that it is one aim of science education to promote competence in evaluations.
- However, in the understanding of most science teachers and science educators this means on the first hand to learn to evaluate scientific data, methods or models – e.g. on climate change.
- The aim is: Students should learn, to assess, reflect and evaluate scientific information.
- This is an evaluation within science.



## An excursus

- But: Unfortunately, only a very small portion of our students will ever come into contact with real science – e.g. real research data and real scientific models.
- Hardly any students will ever come into the situation to really evaluate data or models within science – and if so it will be in one selected field.
- Even us do come into direct contact with authentic information from science research only in selected fields. We are not part of the space where all the other science takes place for most of the science disciplines.

(Eilks et al, *MNU* 2013; Hofstein, Eilks & Bybee, *IJSME* 2011)

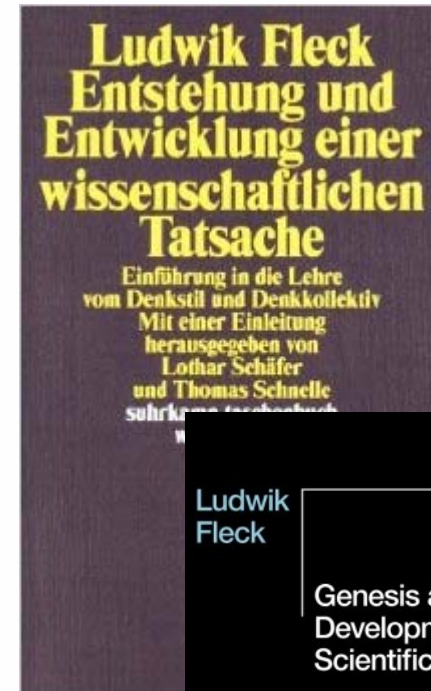
## An excursus

- Original scientific information is available in scientific journals, conferences, debates – but each in a single field.
- Only scientists from the field take access to corresponding information.
- Only expert scientists understand sufficiently the technical language, symbols, math and syntax in scientific articles from what we might call the “journal science”.
- But: As a citizen all of us come into permanent contact with filtered scientific information from other domains, for decisions we might need to evaluate them, but more to evaluate about how science is used and communicated in society.

(Eilks et al, *MNU* 2013; Hofstein, Eilks & Bybee, *IJSME* 2011)



# Ludwik Fleck's theory of the thought collective and the model of filtered information



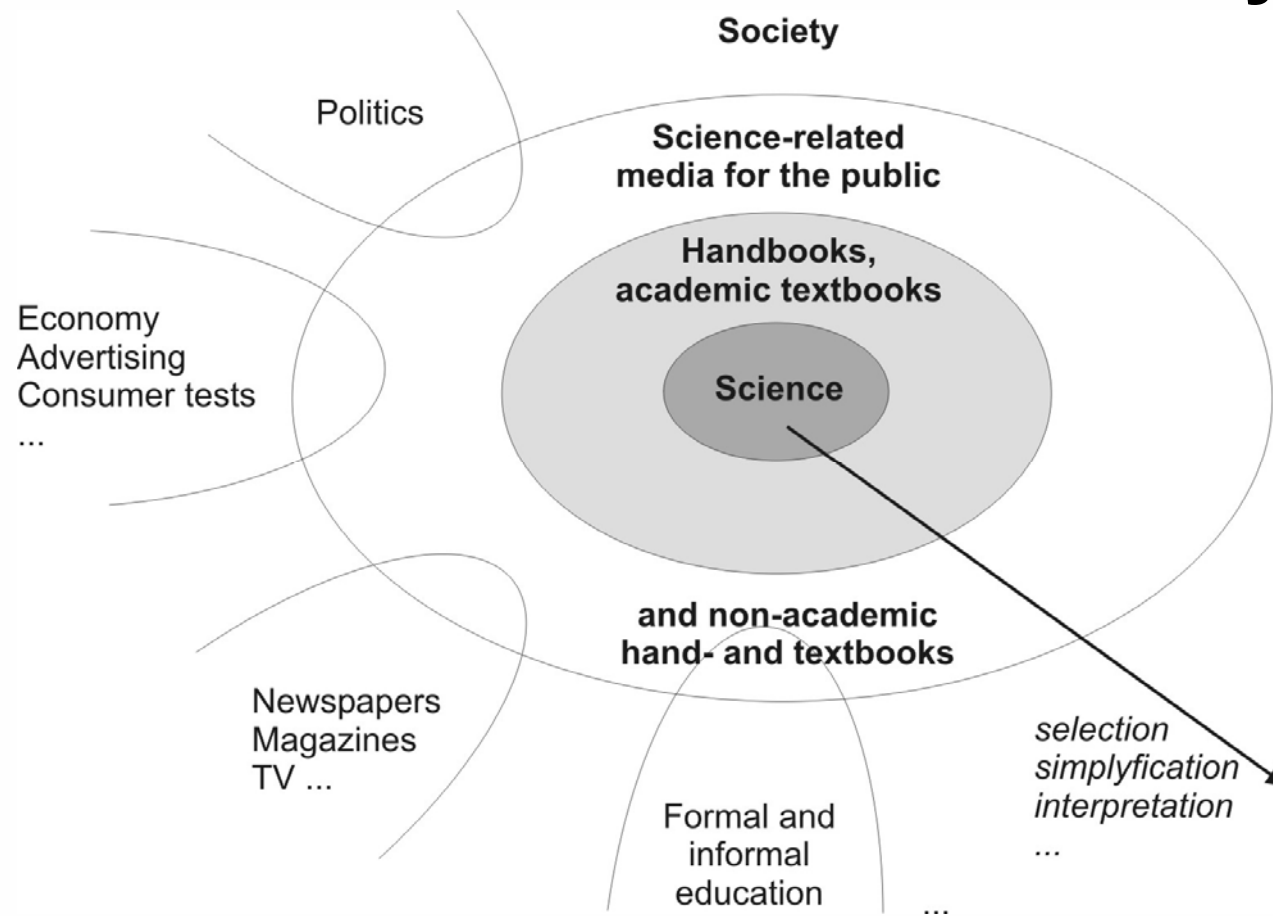
# Learning about ‚filtered‘ information

- Every information about science in our life (beyond our own field of profession) is transferred to us by individuals or the media.
- From the scientific source to us information undergoes a permanent process of selection, emphasizing, and interpretation.
- We might call this the idea of “filtered information”.
- The most filtered media might be advertising. Advertising is intentional and led by commercial interests. Nevertheless, it uses scientific information and one has to be aware about it and how it is used.

(Eilks, Nielsen, & Hofstein, *Springer* 2014)



# The thought collective and the interaction of science with society



(Stuckey, Heering, Mamlok-Naaman, Hofstein & Eilks, S&E 2015)



# The idea of „filtered“ information

science, scientist, scientific information

citizen, non-scientist

(Stuckey, Heering, Mamlok-Naaman, Hofstein & Eilks, S&E 2015)



# The idea of „filtered“ information

science, scientist, scientific information

journalist, politician, advertiser,  
lobby groups, NGOs, PR experts ...

citizen, non-scientist

(Stuckey, Heering, Mamlok-Naaman, Hofstein & Eilks, S&E 2015)

# The idea of „filtered“ information

science, scientist, scientific information

selecting, understanding, connecting to prior, knowledge,  
being interested (or not), being enthusiastic (or not), ....

 journalist, politician, advertiser,  
lobby groups, NGOs, PR from economy ...

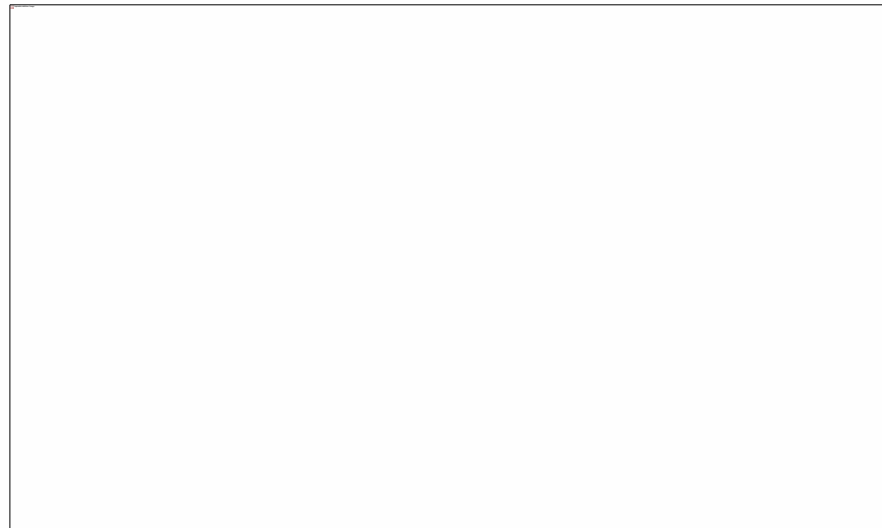
capabilities in explaining, writing, illustrating, ....  
tryings to be objective, pushing interests, ....

citizen, non-scientist

(Stuckey, Heering, Mamlok-Naaman, Hofstein & Eilks, S&E 2015)

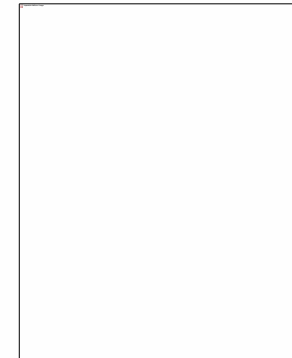
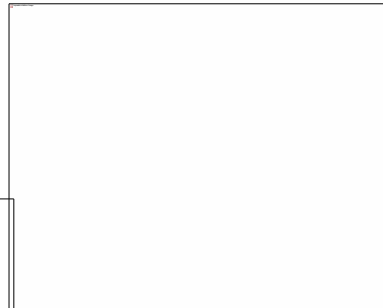
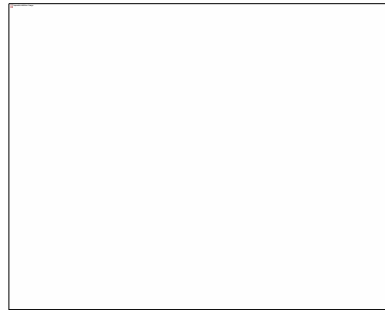


# The right topics, and an inquiry-oriented approach to them



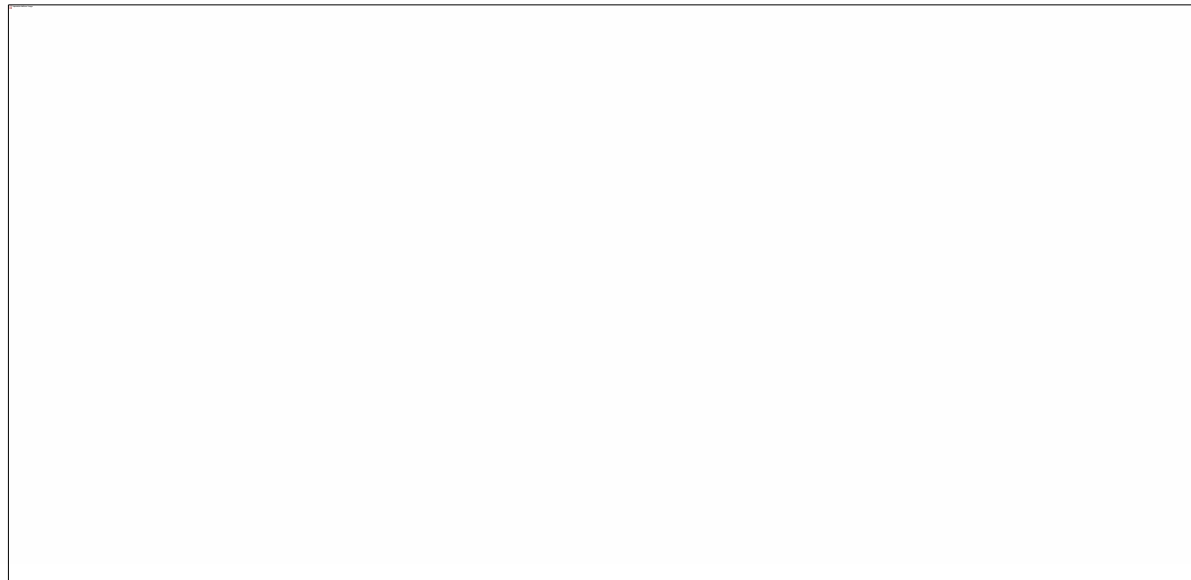


# Are you doped today?

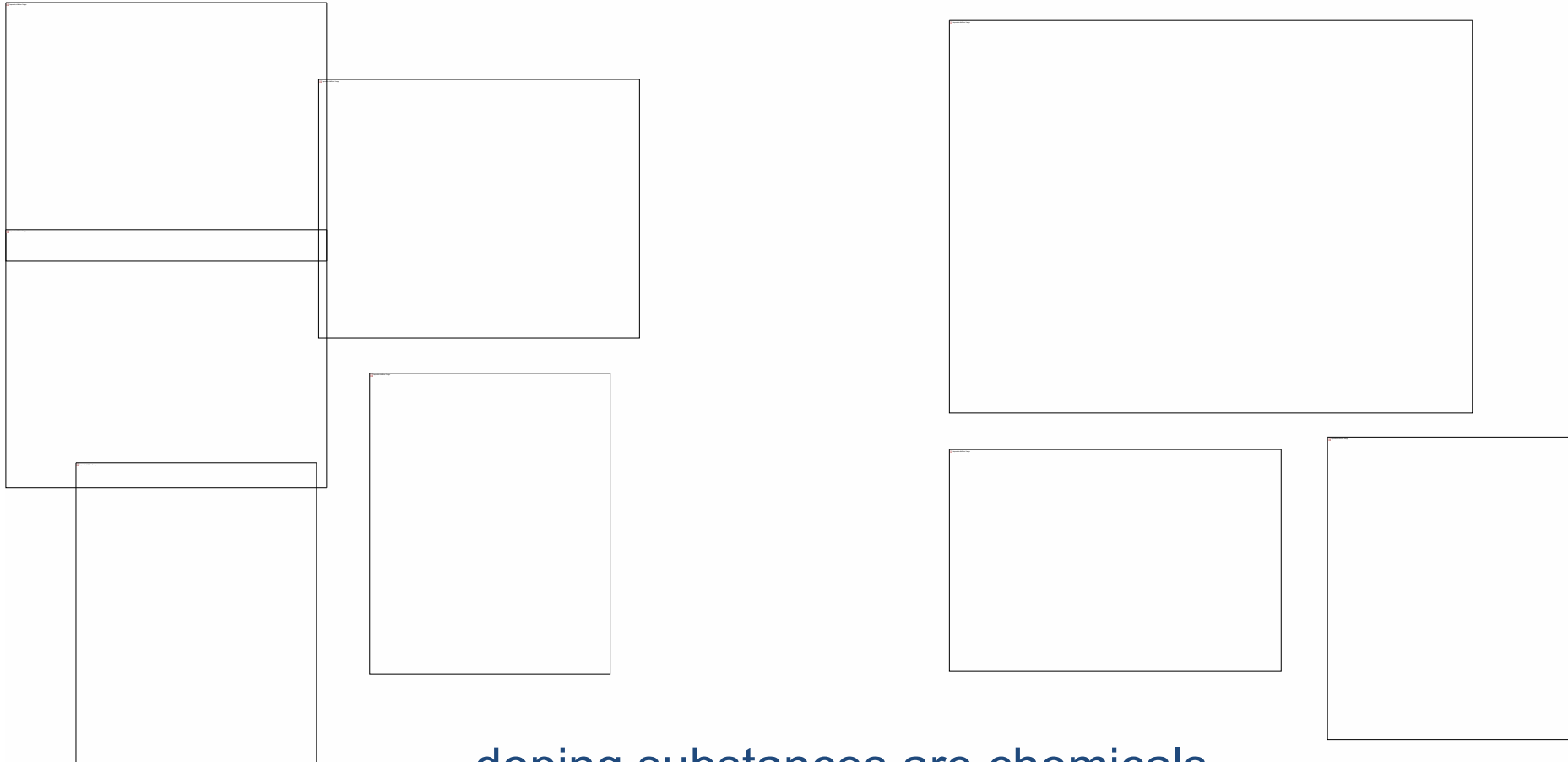




# A chemistry issue that needs evaluations ...



# A chemistry issue, that needs evaluations



... doping substances are chemicals.

... doping is a race of a drug designer and an analytical chemist.

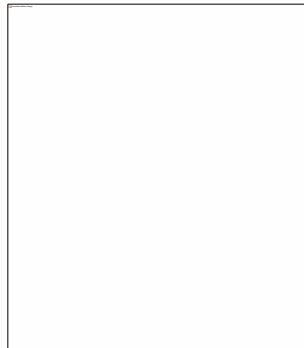




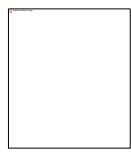
## Many evaluations are needed ...

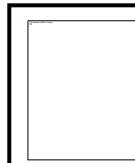
- Most students are TV-consumers of professional sports.
- ..., it is also a question in the fitness studio and in leisure sports.
- Unconscious doping by drugs can happen to everyone.
- The line between food supplements, drugs and illegal doping is often not clear: Who decides?
- Doping in professional sports is controversial, some favour stronger punishments, other suggest to give it free.
- Sports funding and sports industries depend on the prospects of modern doping analytics.
- Biochemistry, medicine, analytics, but also fitness, sports and media offer rich chances for finding a good job in future.
- ...



# Doping

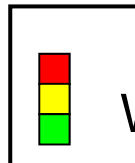


  Using authentic media:  
News reports on doping in professional sports

Inquiring the chemical background/lab:  
Learning on analytical chemistry and doping substances 

 Resuming the socio-scientific dimension :  
Legal, illegal and unconscious doping

 Discussing and evaluating different points of view :  
 Mimicking a TV talkshow

 Meta-reflection:  
 Who is allowed to contribute the discussion and why?

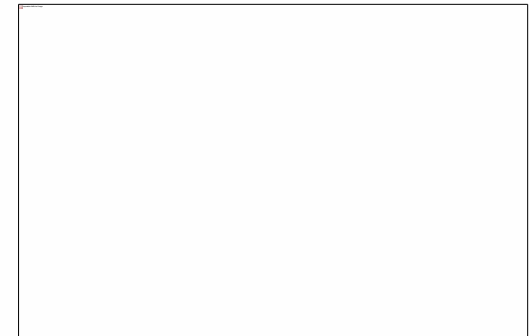
(Stolz, Witteck & Eilks, *MNU* 2011, Stolz, Marks, Witteck & Eilks *EJMSTE* 2013)



## What are the right contexts?

The most suitable topics are

*“... those which encourage personal connections between students and the issues discussed, explicitly address the value of justifying claims and expose the importance of attending to contradictory opinions.”*

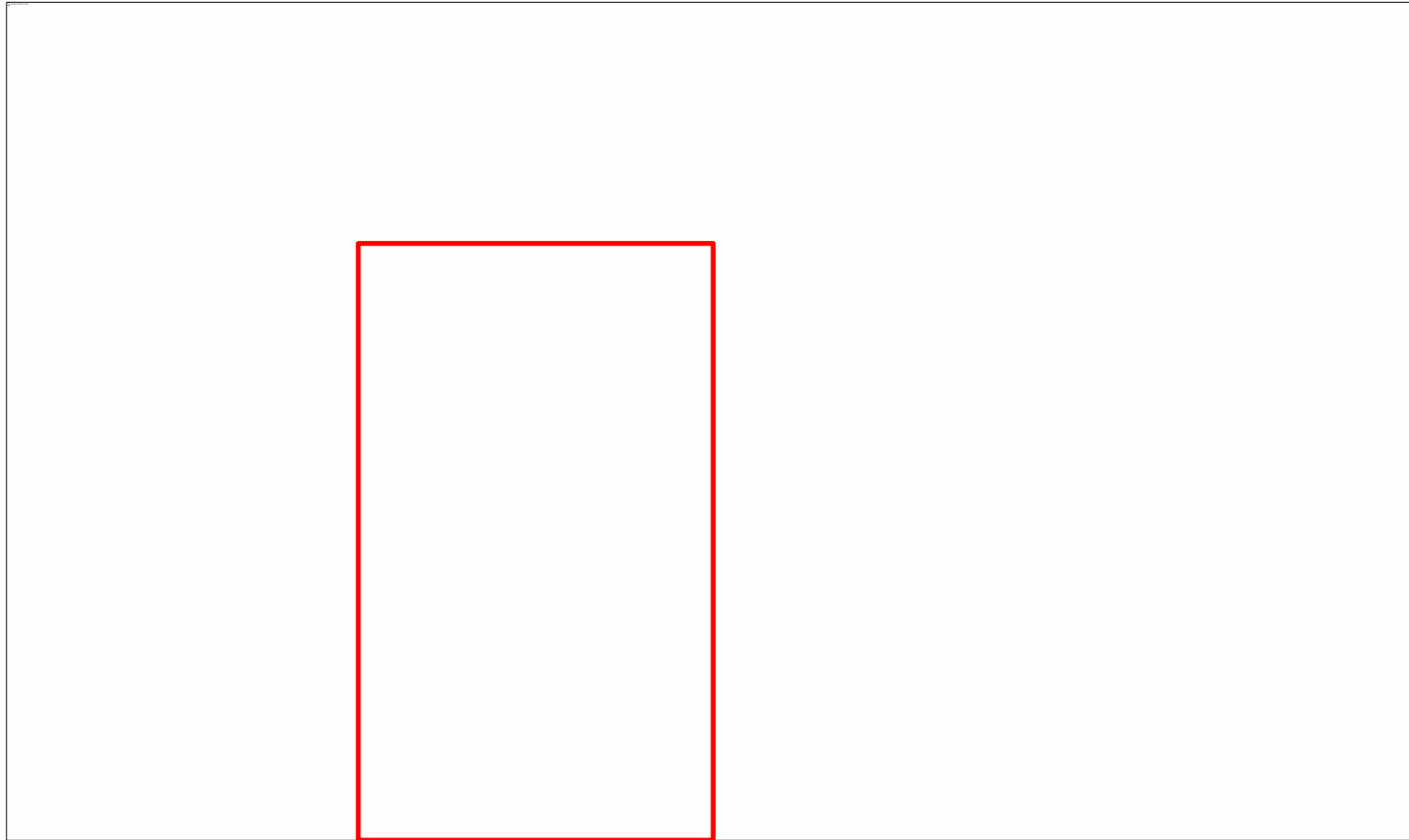


<http://education.ufl.edu/news/2009/02/>

(Sadler, *JRST*, 2004)



## Criteria for the right issues



(z.B. Marks & Eilks, *IJESSE* 2009)



## Criteria for the right issues

- **Authenticity:** Is there a real question and discussion taking place in the public and the media?
- **Relevance:** Are there any decisions to come that make a difference, can corresponding scenarios being outlined?
- **Open evaluation:** Are there in fact alternatives for decisions to come, are there contradicting suggestions available in the public and the media?
- **Debatability:** Can one take any stance to the issue without getting under pressure, can we outline corresponding discussion scenarios?
- **Reference to science and technology:** Is this a question of science and technology, are related arguments used in the public debate?

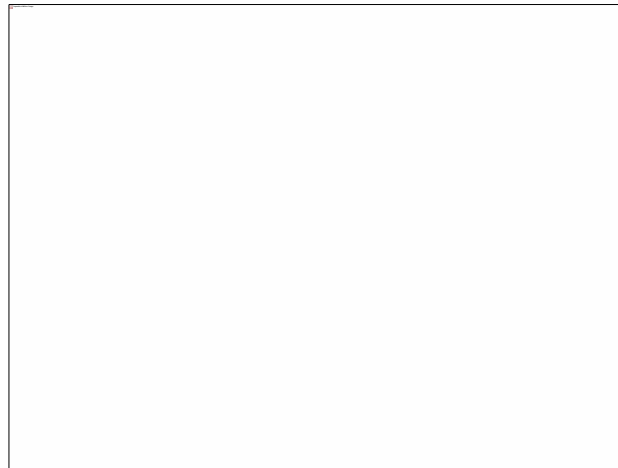


## Many more issues worked out?

- Musk fragrances in shower gels
- Doping in professional and leisure sports
- Light-Produkte/Low-fat- vs. Low-carb-diets
- Taxes on alcopops or energydrinks
- Bio- vs. conventional plastics
- Diets with chitosan as fatburner
- Limiting the personal use of triclosan
- Promoting the use of biodiesel oder bioethanol
- Nano particles in sun protection cremes
- Allow or prohibit the use of stevia as a sweetener
- Lowering the age for legal piercing
- ...



# How is science evaluated: Mimicking authentic societal practices – and a second example





## Another relevant issue that needs evaluations

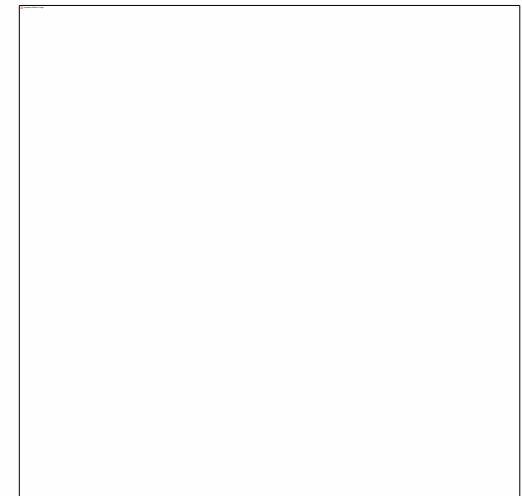


(Stuckey & Eilks, JCE 2015)



# The start

- Students perform a fictive self-test from a youth magazine.
- 14 questions focussing individual, societal, and science-related issues: Which tattoo type are you?
- Every single choice answer gives 1-3 points.
- The overall score indicates whether you are for or against tattooing.
- Students reflect whether there should be questions related to science, the properties of substances, health issues, etc.



(Stuckey & Eilks, CERP 2014)

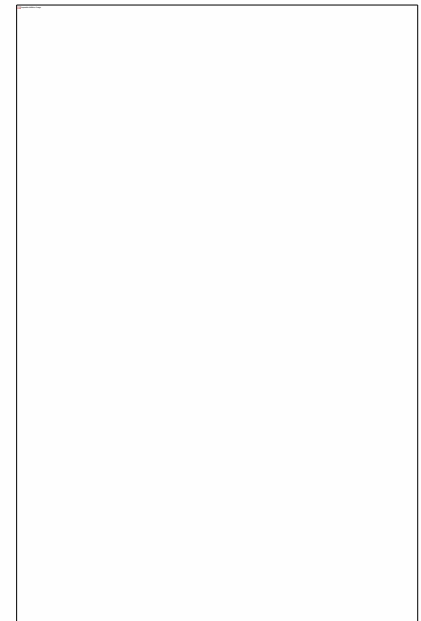
## Tattoos, colours and pigments

<input type="checkbox"/>	Textual approach and problem analysis: Doing a youth magazine self-test
	Clarifying the science background/lab: Inquiring cheap and certified tattoo colours
<input type="checkbox"/>	Resuming the socio-scientific dimension: Under which conditions is tattooing safe
	Discussing and evaluating different points of view: Answering a letter to a youth magazine <input type="checkbox"/>
Meta-reflection: Reflecting about science in youth-related media	

(Stuckey & Eilks, CERP 2014)

# *To evaluate themselves*

- **A letter to the editor's basket**
  - A letter comes to the „letter to the editor“ section of a youth magazine, or „Dr. Sommer“.
  - A 15 year old boy wants a tattoo, but the parents do not allow.
  - Students are asked to respond.
  - Students have to decide, how to answer, which arguments to take, whether to use science-related arguments, and how important are these in comparison to individual and societal arguments.



(Stuckey & Eilks, CERP 2014)



## **Other worked out pedagogies that mimic societal evaluations and decision making**

- Mimicking a TV talk show in a role play.
- Performing a fictive parliaments expert hearing.
- Working as a journalist to prepare short newsspots for TV based on selected Google hits.
- Discussing issues in an Internet forum while inquiring into them
- Creating advertising based on positive and negative properties of the ingredients.
- Performing a consumer test on competing products following given, but self-weight criteria.
- ...

What is the result?

Giving the students the floor...



## Giving the students the floor

- *“The most important issue was to learn, that there can be toxic substances in tattoo colours. And that you should better think three times whether to get a tattoo”*
- *“Later, I would like to have a tattoo. Now I know that I will ask the tattoo artist which kind of colours he is using.”*
- *“I liked the lesson plan for the last hours. I enjoyed it to learn so many different things about tattooing.”*

(Issue “Tattooing“, grade 9 science, age ~14-15)



## Giving the students the floor

*“We have seen, [...] that all the products have advantages and disadvantages. Of course, in public the interest groups present only the products' advantages, because that's positive for themselves, too. They don't mention the disadvantages. So they are opinion-based ... we [the public relations experts] wanted to promote sales of the crisps and did not say any negative things about them.”* (Issue 'Low-carb and low-fat diets', grade 10 chemistry, age 15-16)

*We learned about “a critical re-thinking about issues where the answer originally appeared to be so easy.”* (Issue 'Bio-Ethanol', grade 10 chemistry, age 15-16)

(Marks, Bertram & Eilks, *CERP 2008; Feierabend & Eilks JCE 2010*)



## Giving the students the floor

*„I think that it is difficult to have an opinion to this question. On the one hand, there is the ‘danger’ for the environment when synthetic musk fragrances are used. We have to ask ourselves, whether it is more senseful to find a solution to the water purification side of the problem, or to continue research for other ‘healthier’ musk fragrances. On the other hand, natural musks still exist, whereby the problem is that the animals which produce it are threatened by extinction. We can only hope that enough money is dedicated to research efforts.“ (Issue ‘Musk fragrances in shower gels’, grade 10 chemistry, age 15-16)*

(Marks & Eilks, CERP 2010)



## Giving the students the floor

*"I learned a lot about the production, structure, use, advantages and disadvantages of bio-diesel. Also, I consider it to be important that I learned about our environment and its protection. I especially learned about how companies sell environmental friendly products and how naive we can be if there is the syllable 'bio' in it." (Issue 'Bio-Diesel', grade 11 chemistry, age 16-17)*

*"I have learned about the advantages and disadvantages of Bio-diesel, about interests of pressure groups and how to evaluate their opinions by considering their particular interests, and how to develop an opinion and make up my own mind." (Issue 'Bio-Diesel', grade 11 chemistry, age 16-17)*

(Eilks, CERP 2002)



**Thank you.**

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