What and how are students learning through constructing representations in science?

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Four Questions

1. What is a representation in science?

2. What are students learning by constructing their own representations in this subject?

3. What enables this learning through representation construction?

4. How should these processes and outcomes be researched in future?

What is a representation in science?

(Historicist, epistemological, socio-semiotic, cognitivist, psychological perspectives)

1. History of science as a quest for objectivity/accuracy through visual virtues. From belief in idealized models of, fidelity to, “nature”, in 1800s, to trust in mechanical objectivity in image production, to creative nanotech presentations this century (Daston & Galison, 2007)

2. Socio-semiotic set of multi-modal conventions for reasoning and communicable claim-making by individuals/groups (Latour, 1987; Lemke, 2002; Lotman; 2001)

3. Interactive epistemological tool for sense-making by individuals (Kirsh, 2010; Lehrer, Schauble, Carpenter & Penner, 2000)

Goethe (1798)

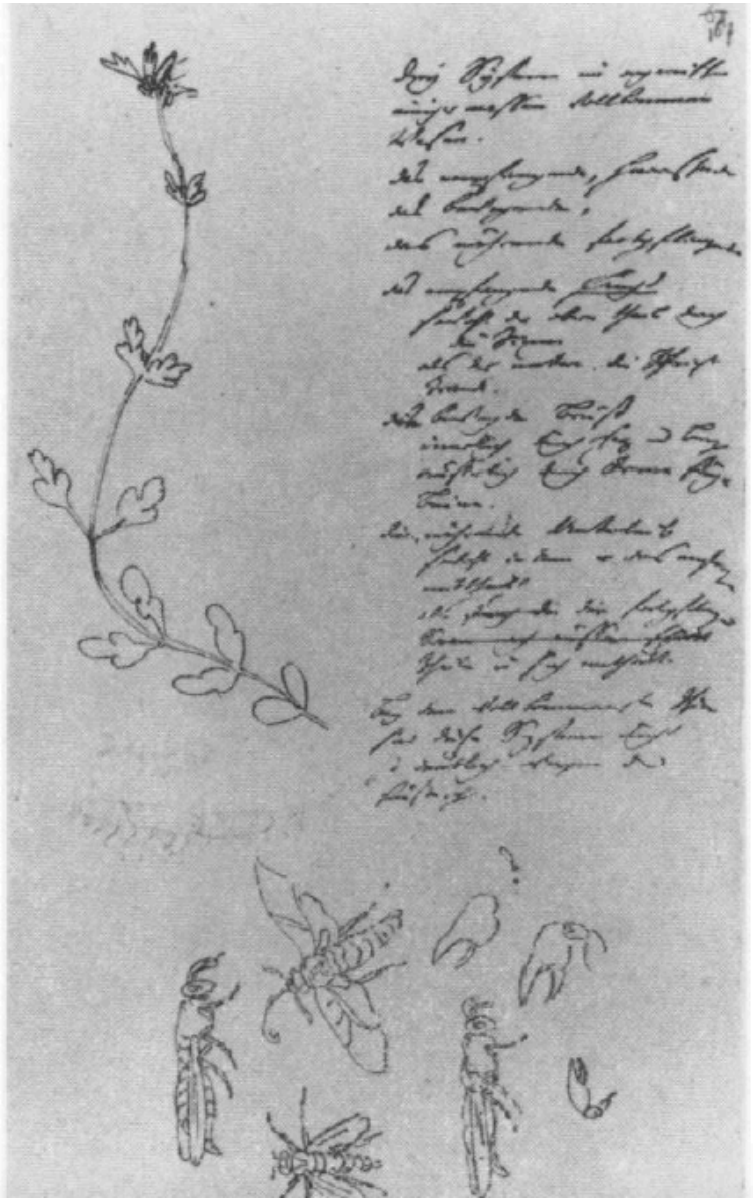
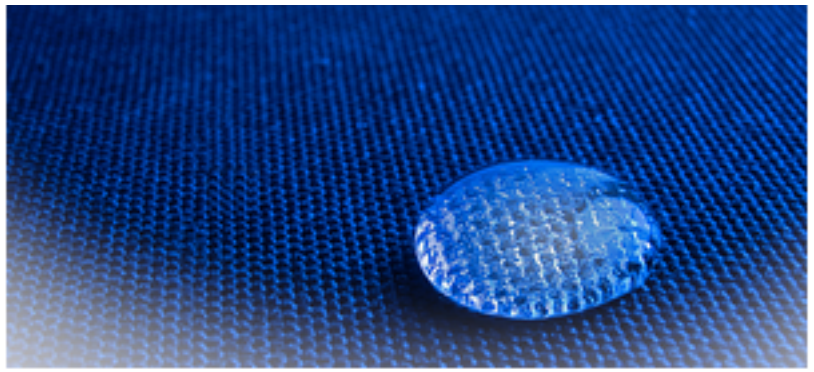


FIGURE 1. The *Urpflanze*, Goethe's sketch of the "*typus* of a higher plant and insect," meant to represent no plant in particular but rather the morphological prototype from which all higher plants can, in principle, be derived. Reproduced from K. Lothar Wolf et al., eds., *Goethe: Die Schriften zur Naturwissenschaft* (Weimar, 1947–1986), vol. 9a, *Zur Morphologie*, ed. Dorothea Kuhn, pl. 9.



Water Droplet on Nano-Enhanced Textile (Source: Plasmatreat.com, 2013)

What is a representation in science?

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What are students learning by constructing their own representations?

- Learning how, when and why to use visuo-spatial, mathematical and linguistic reasoning to make, judge and share multi-modal scientific claims (scientific semiosis, Lemke, 2002)

- Induction into the ingrained habits, skills, methods, and dispositions (habitus) of scientists. Learning to use these reasoning moves and practices first-hand to construct, understand and apply science concepts, models, processes, and explanations to a range of contexts (Tytler, Prain, Hubber & Waldrip, 2013)

- Knowing why and how to proceed in scientific inquiry processes and claim-making, "epistemic cognition" and epistemic virtues (Greene, Sandoval & Braten, 2016)

- In rep construction, students are learning both to know how to seek reasons as well as to give reasons (creative and evaluative aspects of rep construction) (Mulnix, 2012)

- Knowing how to participate in the discourses of science to develop a science-literate identity (Prain & Hand, 2016)

What enables this learning through representation construction?

- Working with external reps has advantages over purely mental work in coming to know/understand because use of external mechanisms (distributed cognition) allows us to: bootstrap to new ideas and new ways to manipulate ideas; coordinate and encode structures of greater complexity; harness more complex simulation processes; re-arrange and share identifiable objects of thought; specify, develop, refine, compare, recast and archive understandings and claims (Kirsh, 2010)
- Embodied contexts, inquiry, manipulation of material objects, and perceptual clues contribute to this learning (Barsalou, 2008; Magnani, 2007)
- Students invest signs with meaning through making imaginative connections between their intentions, experiences, logical structures in sign organization, and use of past scientific meanings (Hodges, 2005; Peirce, 1931-58)
- Students imaginatively fill a perceived ontological gap with explanatory meaning/claims (Latour, 1999)
- Students come to understand and use affordances of different reps to address rep challenges, supported by feedback on rep adequacy to purpose, and comparisons with relevant authorized accounts (Tytler, Prain, Hubber & Waldrip (2013)
- Students learn through re-purposing and re-describing inscriptions (Lehrer & Schauble, 2012)
- Students use aesthetic preferences to personalize meaning investment (Wickman, 2006)

How should these processes and outcomes be researched in future?

- Focus on connecting science and mathematics developmental inter-disciplinary learning through representational construction and critique.
- Connect microgenetic and longitudinal studies of representational/conceptual learning in both subjects.
- Use of design experiment methods, including a systematic cycle of planning, trialing, data generation and evaluation of learning in case studies.
- Need for multiple re-representational data sources to identify teacher and student intentions, reasoning processes, use of embodied/material/symbolic resources, perceived significant/useful aspects of reps and rep manipulation, and the shape of classroom discourse.
- Need to track student assessment of the adequacy of their reps to their own understanding as well as perceived communicative rep adequacy, and contextual effects of whole-class and sub-group negotiations of intended and realized meanings and consensus/disagreement.

VERİ/ GÖZLEM, GRAFİK, DENKLEŞTİRİLMİŞ DENKLEM VE HESAPLAMALAR:

GÖZLEMLER

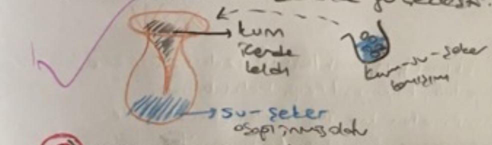
Kum-su → katı sıvı heterojen
Su-şeker → katı sıvı homojen

(1) Katı – Sıvı heterojen maddelerin birbirinden ayrılması

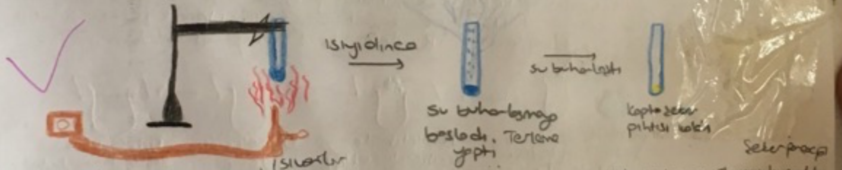
— Kum - su - şeker ayrımı —

a) Beherin içerisine bir miktar kum ekledim. Üzerine bir miktar su ekleyip karıştırdım. Üzerine bir miktar şeker ekledim. Karıştırmama rağmen kum dağılmadı, şeker çözündü. Olabildiğince yerleştirdiğim (Hatice Hocama teşekkürler yardımları için) süzme kağıdını kapsayan ayırma hunisinin üzerinden bu karışımı yavaş yavaş döktüm. Erlen içine süzme kağıdında sadece kum kalırken, erlene düşenler şekerli su kaldı. Süzme bu şekilde gerçekleşti.

Melikecim rica ederim =)



(2) Daha sonra şeker – su karışımından direkt olarak cam tüpün içerisine ekledim. Bu karışımı kıskaç düzeneği ile tutturup bunzen beki ile orta derece ısı ile ısıttım.



Böylece kum-şeker-su karışımı, kum süzme ile, şeker-su buharlaştırma ile ayrılmış oldu. Buharlaşan suyu da tekrar yoğunlaşma ile elde edebiliriz.

(3) Sıvı – Sıvı Heterojen Zeytinyağı – Su karışımı

Beherin içerisine bir miktar su ve bir miktar zeytinyağı koydum. Zeytinyağı yoğunluğu küçük olduğu için suyun yüzeyinde kaldı su dipte kaldı. Kurmuş olduğum (hatice hocama teşekkürler) (fatma hocama teşekkürler) düzenek üzerinde ayırma hunisine beherde olan maddeyi döktüm. Altında bulunan dereceli silindirin içine huniden sadece su boşaldı. Çünkü suyun yoğunluğu daha büyük. Böylece zeytinyağı – su karışımı ayrılmış oldu.

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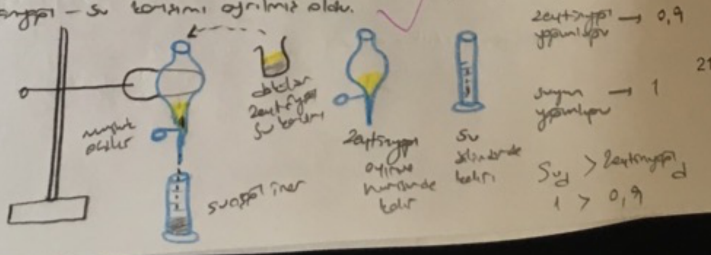


zeytinyağı yoğunluğu → 0,9

suyun yoğunluğu → 1

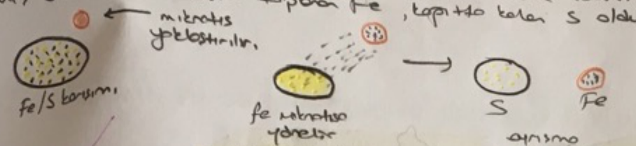
su$_d$ > zeytinyağı$_d$

1 > 0,9

(4) Katı – Katı

Fe / S → mıknatıs

Süzme kağıdının üzerine bir miktar Fe ile bir miktar S aldım. Spatül ile iyice karıştırdım. Eşarbımın mıknatısı ile deneyimi daha da canlı hale getirdim. Karıştırılan düzeneğin üzerine mıknatısı yaklaştırdım. Mıknatıs doğal olarak kendi cinsinden olan demiri kendine çekti. Böylece karışımı ayırmış olduk. Mıknatısta toplanan Fe, kağıtta kalan S oldu.



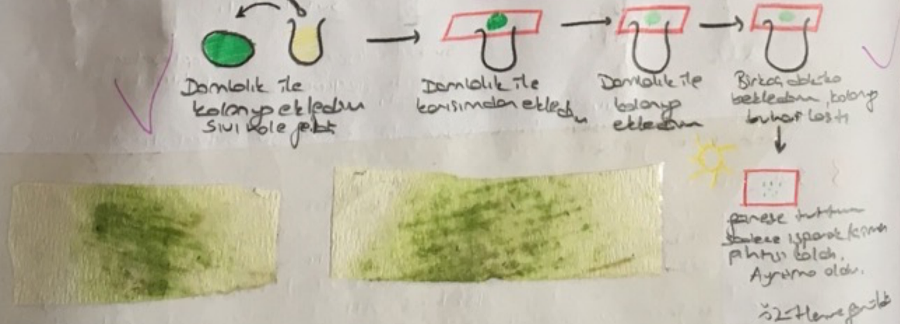
Deneyin grafiği :)

(S) (Fe)

(5) Özütleme

Ispanak / Çimen / kolonya

Porselen kabın içerisinde (havan şeklinde), ıspanak (çimen) ezdim. Üzerine kolonya döktüm. Cıvık ve sıvı hale geldi, koyu yeşil renk halinde idi. Beherin üzerine ayırma kağıdı koydum. Porselen kap içerisinden damlalık ile bir kaç damla karışımdan aldım ve süzme kağıdına koydum. Yeşil halka oluştu. Birkaç dakika bekledim. Üzerine yine damlalık ile bir kaç damla kolonya ekledim. Yeşil olan dairesel en açık yeşil olan fıstık yeşili halka oldu. Yine bir kaç dakika bekledim, kolonya buharlaştı ve yok oldu. Kağıdı güneşe doğru tuttum ve kağıt üzerinde ıspanak / çimen pıhtılı kalıntıyı gözlemledim. Böylece karışımı ayırmış oldum.



(6)

renginde açılma oldu

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Methodological Challenges

- Manageable complexity?
- How do we evaluate what we can know from our methods?
- Mapping kinds of reasoning?