European Commission

Portfolio

methods, tools and materials for linguistic and cultural sensitive science teaching

for Science Teacher Education

ESTA
Educating Science Teachers for All

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Need for the Changes within the Project ESTA in Science Teacher Education at our University

Ilia State University educate future science teachers in Georgia and also provide in-service science teacher training. Cultural and linguistic diversity is a big challenge in science teaching. Special courses focusing on language learning and cultural issues in Georgian science classes was missing from the teacher training curriculum.

The aim of the ESTA course is for the student to acquire knowledge about bilingualism and bilingual teaching models, about CLIL approaches and develop the so-called ability of linguistic sensitivity to be able to identify the different linguistic abilities of non-Georgian speaking students and to include them equally in the process of assimilating the subject content of science in the Georgian language, taking into account their linguistic abilities.

After completing the ESTA course the student will know ways to achieve the goals of science teaching at the elementary level while working with non-Georgian speaking students; Also will be able to determine the student's previous linguistic knowledge when teaching science issues; It will be possible to properly support students with language difficulties in teaching natural language, both in the direction of reception (understanding what is heard and read) and production (expressing an opinion orally or in writing, participating in a discussion).

Collection of Methods, Tools and Instruments from the University of Limerick and Ludwigsburg University of Education

Methods, Tools and Instruments for dealing with linguistic diversity

Home/Academic Staff Tour/Workshop 1: Planning our Teaching

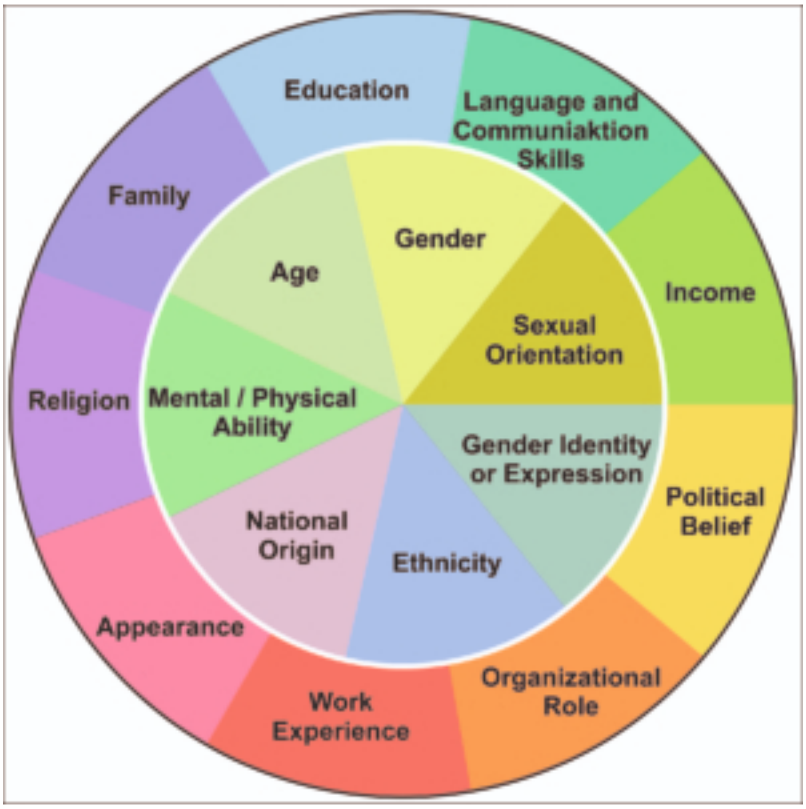
Workshop 1: Planning our Teaching

How do we plan our seminars?

In the following we would like to present how we develop our seminars when we think about developing our future science teachers` competences to deal with heterogeneous classes in their future.

Different dimensions of Diversity Wheel

Our students bring different dimensions in our classes. Those are presented in a *Diversity Wheel*. Most of those we don't even notice but they are there and influence our students learning in general and science in particular.



Here you can find more information about diversity wheel

The majority of our university students (about 98%) went to academic track school during their whole primary and secondary education. Thus, most of our students never experienced high heterogeneous classes. One of the studies showed that for our groups of students, heterogeneity

and diversity means that students can get different marks in chemistry. Different dimensions of diversity were not present in their schools, and if present then not noticeable.
Discuss in your team: What about your future science teachers? Are they aware of the different dimensions of diversity and how this may influence science teaching?
Thus, our seminars are planed in three steps: In the last years, we worked on different methods for making our students sensitive for different dimensions of diversity.

In this publication you can find some methods, for the three named steps.

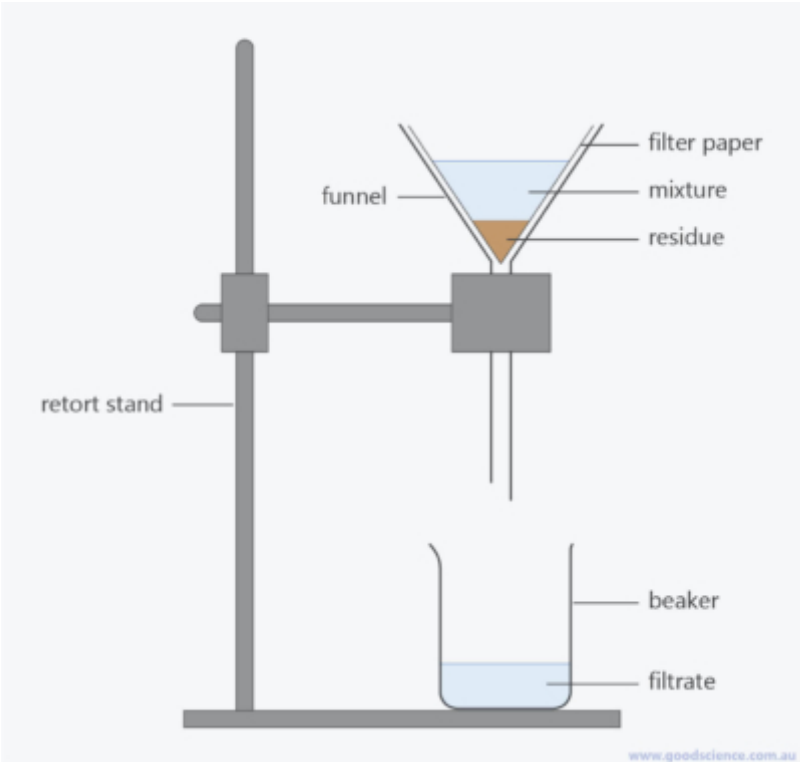
Home/Academic Staff Tour/Workshop 2: Language and Science Education

Workshop 2: Language and Science Education

Next to the differences in science knowledge, teachers often name *differences in students' linguistic competences* as an obstacle for teaching and learning science.
Discuss in your team: what language(s) do students in your science classes speak? Don`t forget the language of science. Here you can find more information.

I. Making science students teachers sensitive for linguistic heterogeneous classes

Starting with the paper in Workshop 1 the question is: How to make my student teachers sensitive to language differences in their science classes?



Filtration

Sensitization

The first method we use is starting the seminar in English and also asking student teachers to talk in English. Usually, we introduce one simple experiment (e.g. filtration of sand and water). We present the experiment and explain/talk what we are doing. Finally, students need to write a lab report on their own. In the next step, they need to compare it with a peer and finally with another three peers, following the method "*1-2-4-all*". The goal is not to write and have a "perfect" lab report but more to reflect on how they felt while doing such an activity. In the last paper in workshop 1, you can find some questions to guide the reflection.

A second method is the use of role-play. Student teachers play the role of students in a mock science class and each of them plays the role of the student described on a card they get at the beginning of the role-play. Depending on the number of the student teachers in the course, the number of roles will be different: about 70% of the pretend students are "normal students" (somebody who does not cause any problem in the class, is not one of the best but also not the worst considering knowledge), 1-2 high achievers, 1 student with language problems (e.g. refugee), one student from a lower social background, one to two students with special needs (e.g. one is sitting in the teacher's chair with wheels or one student has earphones). One student is usually autistic.

The student teachers take on the role of the class and they need to conduct an experiment. This differs, depending on the room: sometimes we are in the lab and perform an experiment, but sometimes we are in our seminar room. In the seminar room, we can not experiment, but here the experiment is called “which skittle colour is most represented in the bag?”
The questions for the reflective activity can also be used here.

II. Making science students teachers diagnose in linguistic heterogeneous classes

Next step is teaching student teachers about conducting diagnostics in science classes.
We do this in two steps.

1. First we give a short presentation on performing diagnostics which is based on the following paper. To inform student teachers about different tools for performing diagnostics, we use the following tool. This is something that our student teachers read at home and so prepare for the class. The presentation can be recorded and uploaded or different free videos (e.g. from youtube or different platforms).
2. In the second step, which is in the class, student teachers develop diagnostic instrument for one topic from science lessons. For this, they use their knowledge from the preparation and the Prezi Tool. Student teachers usually work in groups of 3 and use *Google docs* which is created by the lecturer. They usually do this during the class and after about 20 minutes, the lecturer enters the google docs and comments on their work. This also works very well online.

Discuss in your interdisciplinary team: How can those instruments be adapted to your language and country?
(if you want to use the Prezi tool and adapt it, please send Silvija an email. For adaptation, you need to have Prezi account).

Workshop 3: Language and Science Education – Part 2

In the second workshop ideas and methods were presented which can be used to make science (student) teachers sensitive to the heterogeneity and diversity in science classes. Furthermore, we summed up the ideas on how (student) teachers can diagnose languages, knowledge, etc. in science classes.
After being conscious of the differences and diagnosing those differences, it is time to deal with it in science class.

III. Making science students teachers deal with linguistic heterogeneous classes

Phase 1

Before starting the topic of dealing with linguistic heterogeneity, in our seminars, we want our student teachers to have practical experience with this topic. For this, we divide the whole group of students into smaller groups of three or four. Each group gets access to a google doc sheet which contains a scan (or similar) of a page of a textbook, or working sheet, etc. Their topic is, to discuss in the small group about the single parts of the page which could be especially difficult for usage in language heterogeneous classes. They should also make notes on this in a google doc. After about 15-20 minutes, we join the single google doc files and comment on students` work using the comments. Here, students also ask questions they were not able to answer in the group.
During the time of online teaching, via zoom, we start the session with a Kahoot game on diagnostic. After that, the small peer-groups were sent to different breakout rooms and were able to discuss here instead of face-to-face.

Phase 2

The next phase is more theoretical in nature. Student teachers should work on tools and methods on how to deal with language heterogeneous classes. For this, first, they need to see this video on CLIL and work with the Prezi on "*Methods for language sensitive science teaching and learning*".

Phase 3

This phase is similar to the first one. Student teachers work again on the small peer-groups and the topic is to develop new or change the given page from phase I which is now language sensitive. They can use any methods presented in Prezi. Also here, after about 15-20 minutes we join the google docs one after the other, comment on their work, give feedback, ask questions but also answer student teachers` questions.
Discuss in your interdisciplinary team: How can those instruments be adapted to your language and country? (if you want to use the Prezi tool and adapt it, please send Silvija an email. For adaptation, you need to have Prezi account).

Workshop 4: Interest and Science Education

What is Interest?
Interest as a multidimensional psychological construct that incorporates elements of engagement, attention, motivation and curiosity. Given this, interest can be difficult to define or measure in a research sense but can (and should!) be fostered in learning environments. Teachers know it when they see it and the positive impact of interest-driven pedagogies can be drastic.
In your interdisciplinary teams, discuss what behaviours or traits you might observe when learners are interested in a science lesson?

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Why is interest important?

Internationally it has been recognised that as a student progresses into adolescence, they become less interested in science. There are a multitude of reasons for this decline and many are out of teachers' hands. However, teachers can influence the content of their science lessons and move away from transmissive teaching styles to interest driven pedagogies.
Indeed, science teaching is the biggest determinant of student interest. Moreover, this interest has been linked to academic achievement and future subject choices. As such, the ability to develop a talent pool in the sciences truly falls into the hands of science teachers who are often under resourced and time stricken.

Components of interest

To be able to change or modify teaching, you have to understand some of the components of interest. In modern literature, interest is broken into Situational Interest (SI) and Personal Interest (PI) (Note that PI is also sometimes referred to as Individual Interest).
SI is a temporary construct that arises due to environmental or contextual factors. For example, an engaging text, visual or new piece of technology may trigger SI among students. Therefore, SI can be nurtured in class by the teacher.

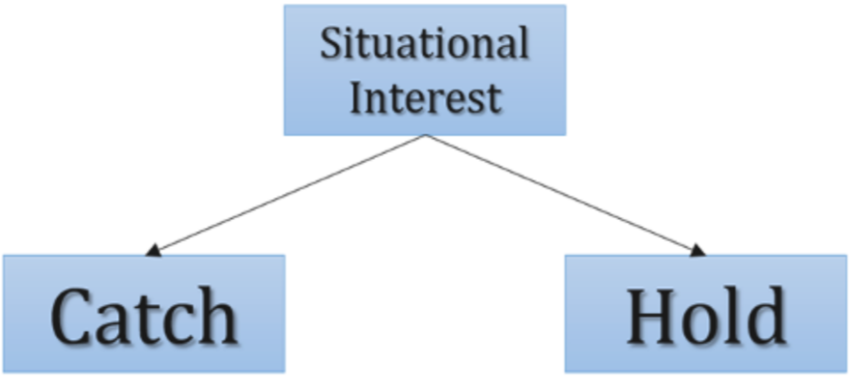

Figure 1: Situational interest has two components 'catch' and 'hold' (Mitchell 1993).

SI can be further broken into two more elements, Triggered SI and Maintained SI. This is sometimes referred to as the 'catch and hold' of interest (Figure 1). Take for example a shooting star. Once observed, it will trigger or catch your SI. However, due to the stars fleeting nature it is unlikely that it will maintain or hold your interest. The same applies to the classroom and teachers should avoid gimmicks or strategies without depth. Of course, trial and error through experimenting with students can reveal what works best for each group.

The triggered aspect (catch) of SI can usually be observed through behavioural changes among students, especially if they report on their excitement both vocally (oohh's and aahh's!) and physically (sitting up straight or trying to see the board or demonstration). This stage is characterised by attention, but it needs to be maintained (held) to be of any educational value. Maintained SI is where a student begins to forge a more meaningful connection with the lesson content. As such, content needs to be relevant and have value.

Teachers should strive to continually impact SI with a variety-based approach. The wider literature claims that if teachers can continually engage a students' SI, they will eventually develop a Personal Interest (PI) in a subject area. PI is a stable construct that is enduring over time. Think of those students who enjoy science all the time even when the quality or type of instruction varies. PI can also be further broken up into two separate constructs. These include less developed personal interest and well-developed personal interest. The difference between the two is essentially the scale and level of interest held by the student. These latter phases are characterised by a positive feeling towards a subject area and a high level of content knowledge. Furthermore, students who are personally interested will persist with difficult content and can be resourceful in tackling problems.

Combining all aspects of interest, Hidi and Renninger (2006) put forward the four-phase model of interest development which can be observed in Figure 2 below. It demonstrates how interest can run on a continuum.

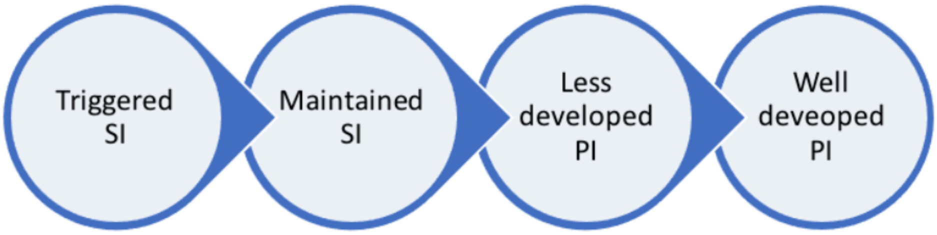

Figure 2: Hidi and Renninger's (2006) four-phase model of interest development.

How to make science teaching more interesting

From a teacher perspective, SI is a malleable construct and there are a wide range of strategies available to make science instruction more interesting. The following will briefly outline a number of techniques. Bear in mind that the list is not exhaustive and many of the techniques can be improved through the use of group work. Social interaction in class is an excellent way of maintaining interest throughout the duration of a lesson.

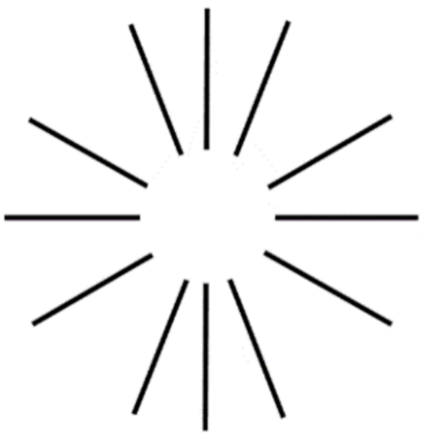

Figure 3: An Ehrenstein figure with radiating lines around a 'circle'.

Discrepant Events

People have one of two reactions to discrepant events (things that do not make sense!). Either they will become interested or confused. Confusion can be turned into interest if the teacher makes sure that any discrepancies are fully explored and resolved.
A simple approach in class is to use intriguing visuals. Take for example the Ehrenstein illusion in Figure 3. The image consists of radiating lines; however, it seems to make the image of a circle inside the lines. An image like this can be used to trigger a student's interest in light, drawing and the eye.

Experiments are also an excellent way of promoting discrepant events, especially if the result can seem magical or non-sensical. A simple experiment that teachers can perform in class is the Gravity Hand Trick. Get one of the students to place a coin in one of their hand stand out of the sight of the teacher. They then raise their hand holding the coin into the air for 60 seconds. Over this time, the blood will rush out of their hand. They are then asked to put their hands together and the teacher picks out the hand that held the coin. The method behind this experiment or trick is due to the difference between the student's hands. The hand that was raised in the air will be paler and less vascular than the one held by their side. Note that this experiment does not work as well with students who have darker skin tones. Given this, it is a good experiment if you want to talk about pigmentation and cardiovascular issues. See Figure 4 below and use the following link to get more information.

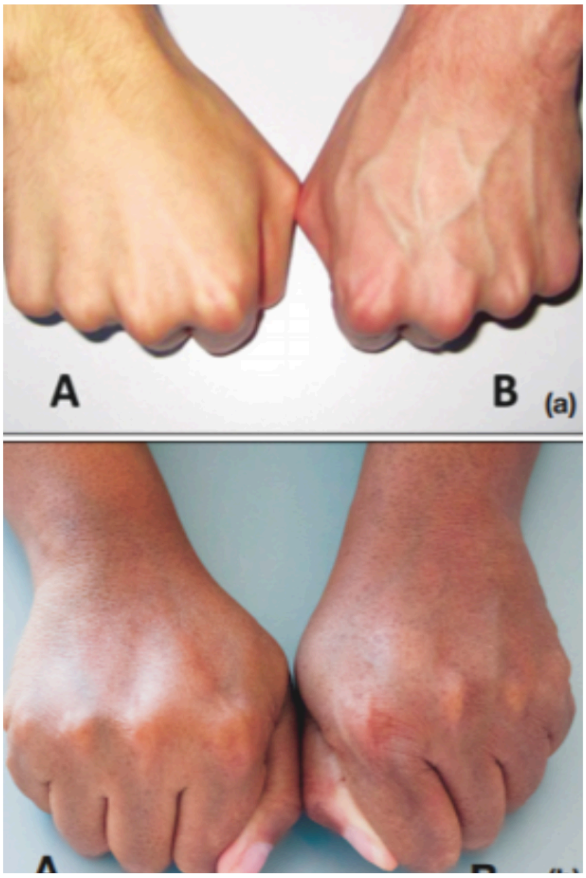

Figure 4: An image demonstrating the difference between different skin tones of students who have both conducted the gravity hand trick.

Relevance

Relevance in teaching can take many forms. For example, in science you may use everyday materials to conduct experiments. This can show students that science is everywhere. A second relevance approach is to use culturally important materials to the students, things that relate to their personal lives and contexts. Finally, a teacher can also make science more relatable by giving students ownership of experiments. For example, in ecology, get students to make and assess their own quadrat (square that is placed on the ground and students take account of all plants and animals within) from their gardens or local parks. With this, the student makes a

personal connection with the topic. An example of a strategy in which students make their own science videos is presented here.
Genetics is a good topic to use relevance to build interest. Usually students are asked to roll their tongues, however, they can look at other traits such as the 'hitchhikers' thumb' in Figure 5. This will make science personally relevant and trigger interest among students.

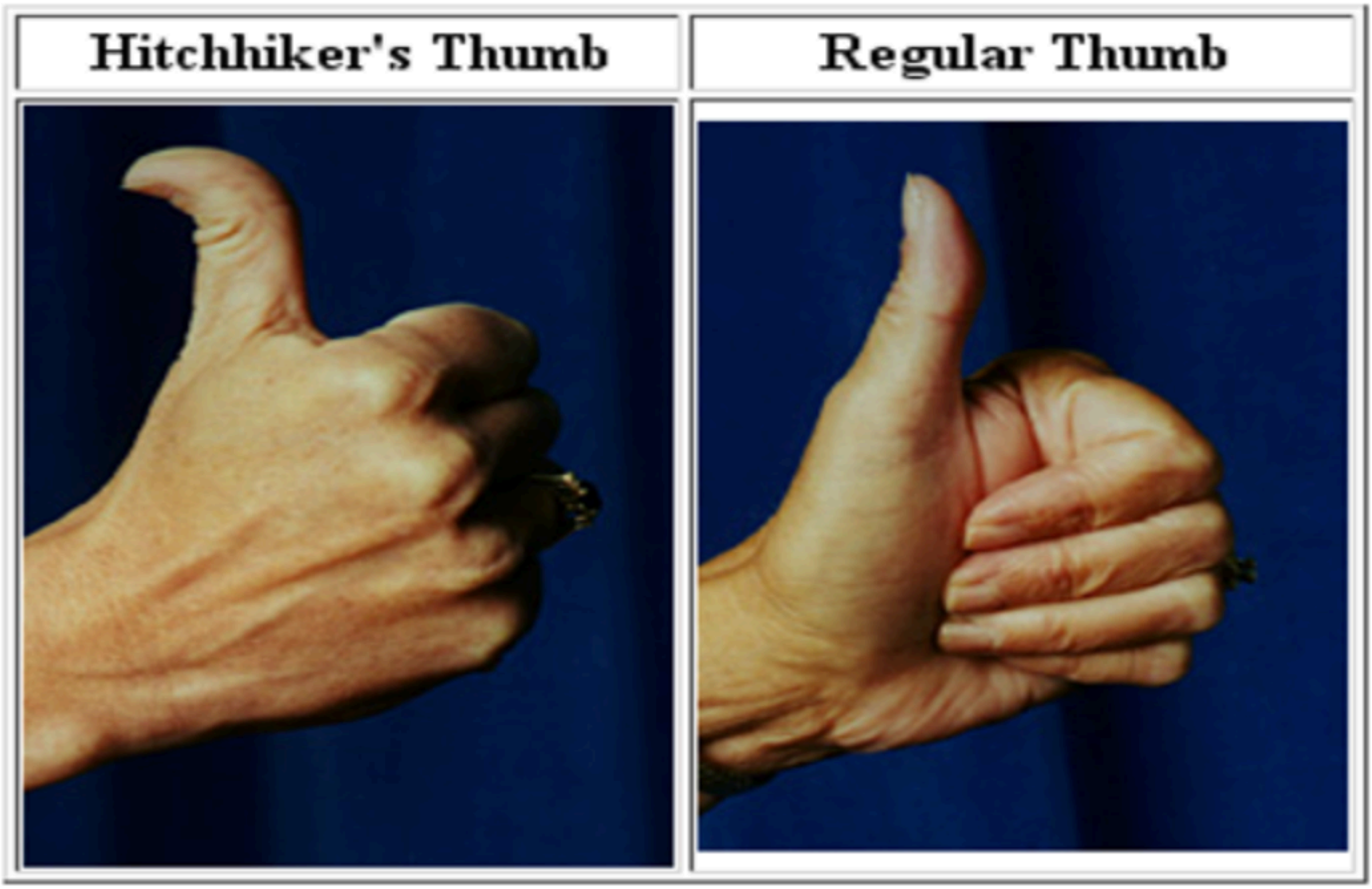

Figure 5: Image with a hitchhiker's thumb and a straight or 'regular' thumb.

Questions and Puzzles

Questioning is one of the most basic ways in which a teacher can engage a student. The type and form of question can directly influence a student's interest. If they can comprehend the question and can offer an answer, then they are more likely to pay attention and engage. In line with the previous sections, questions that are relevant to the student in some way are more engaging, particularly if they can use their prior knowledge. Examples of good questions include

- What is the percentage of water in a watermelon?
- What is the largest land predator on the planet?

These questions are effective because every learner can offer up an answer no matter what their level of knowledge. An example of a bad question is

- Can you define the amp?

This question is highly specific and will immediately disengage those who have little knowledge of the topic area.

Puzzles can also be used for longer term engagement. Take for example the puzzle in Figure 6. Students are given the image on the left. It is an L shape. They are then asked to divide the shape into four sections that are all the same shape and the same size. However, the question can be slightly changed and given a theme. Pretend the shape on the left is a field and the owner is dividing it up for their four children. They want each child to get a field that is the same shape and size to avoid any disagreements. Students can be encouraged to work in groups and use rulers to measure their shape and break it up. The answer to the question is on the right side of Figure 6. There are many other strategies that can be found online. Think about your own context and do some research into inclusive interest-based pedagogies that would work for both teachers and students.

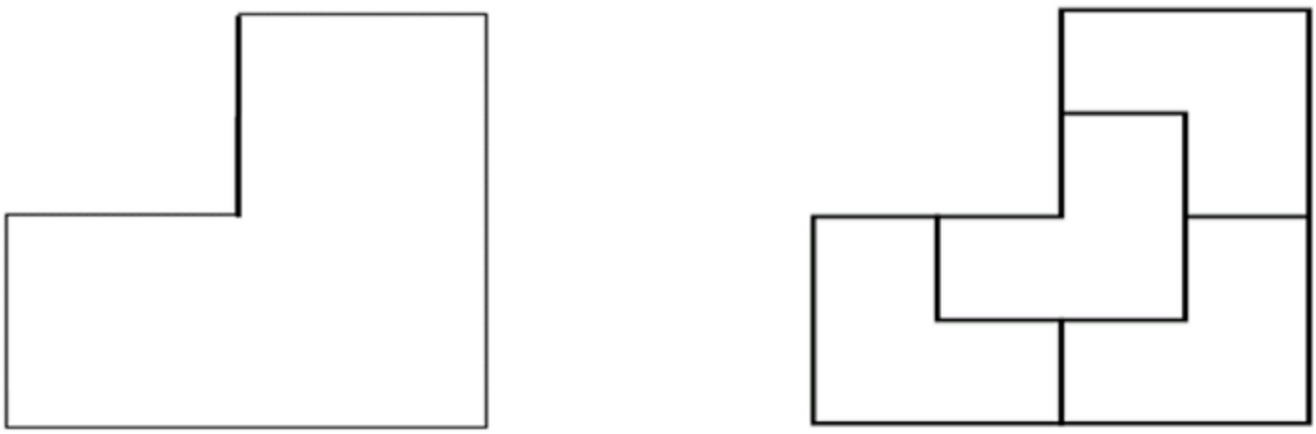

Figure 6: The L shape on the left is first presented to students when setting out the question.

The image on the right is the correct answer.

Measuring interest

If you are interested in assessing student interest or changes in interest over time, there is a wealth of research literature examining both qualitative and quantitative methodologies. If you are new to research and measuring psychological constructs, a qualitative approach with stakeholder interviews, observations, reflective journals and short questionnaires (exit cards) may be the best approach. Most likely, you will not produce publishable data, but you may gain key insights into teaching and interest that will allow you to take the next steps. Qualitative methods are especially effective if you are not sure what will happen or what the impact is going to be in a given lesson. For the more experienced researchers or researcher teachers, a quantitative approach can work well when you know what you want to measure and how it can be measured.

Workshop 5: Culture and Science Education

Is chemistry your thing? Please check on it here.

According to Ayisi (1992, p. 1), culture is " …that complex whole which includes knowledge, belief, art, law, morals, cultural tools, customs, and all other capabilities and habits acquired by man as a member of society." Grosser & Glombard (2008) argue that the cultural environment in which a learner grows up will be a major factor contributing to the development of critical thinking abilities, as well as to question-asking abilities. In East Asian countries, for example, critical thinking is seldom a task involving reading instruction, and students are not required to perform critical reading (Wu, 1982). The lack of emphasis on developing critical judgment in reading instruction is evident in many published teaching guidelines or teacher's manuals (Teaching and Research Department, Shanghai Education Bureau, 1957). For many Asian people, books are often thought of as an embodiment of knowledge, wisdom, and truth, which can be taken out and put inside the students' heads (Maley, 1983). Therefore, they are treated with reverence and great value is attributed to them. In other words, authors are considered authorities. Everything they say in print has to be correct—their opinions, judgments, and conclusions.

Discuss in your interdisciplinary team:
What is typical for your culture and the cultures which are represented in your country. Are there any differences when it comes to the actions of students in the classroom noticeable?
Additionally, studies show that culture and gender interact when it comes to students` self-concept considering science. More information on this are to be found here.
Finally, the home environment and its influence is seen when it comes to self-concept. More information are to be found here. To get detail impression of the study please follow this tool.

Workshop 6: Flipped Classroom

Flipped Classroom has become one of the most attractive, effective and helpful approach.
More information about the flipped classroom approach can be found at the "An Introduction to Flipping the Classroom".

Flipped Classroom Approach is to be found in different settings. In the last years, research on those settings can be found. A summary of the research on "Flipping for Divers Learners" can be useful for your further work and seminars.

Flipping the Teacher Education

Finally, the usefulness of flipped classroom approach founds is way also in teacher education.
More information about are to be found under "Flipping the Classroom in Teacher Education".

An practical example joint by research done on it can be found in following slides and the conference paper.

After exchanging your experiences and knowledge in your team, please let us know in the padlet your opinion, needs but also suggestions/ideas/help to other partners. Thank you.

Workshop 7: Digital media in science teaching

Discuss in your team: Why should students learn with digital media?

10 thesis about digitisation in education

1. will not go away
2. changed what knowing and other basic concepts of education mean
3. opens up new paths and changes the objective.
4. is choice for effective networking
5. enables access to knowledge independent of time and space
6. not only solves questions, but also creates new ones
7. demands new competences
8. releases new potentials
9. means work and confrontation
10. breaks the teacher's monopoly of knowledge and thereby transforms their mission (c.f. Bieler, 2018)

Research

In 2017 Hillmayr et al. (2017) have shown in their metastudy on the use of digital media in science, that students which learned with digital media had better results in performance tests. This positive impact is higher, if traditional material is used in addition to digital media. Also an increase of student' motivation was found.
In exploratory studies, a motivational effect (c.f. BITKOM, 2011; Schaumburg, Tschakert & Blömeke, 2007), stronger cooperation between students (cf. Tutty & White, 2006; Kolle & Singer 2008; Schaumburg & Issing, 2002) and greater media competence was found (cf. BITKOM, 2011; Reinmann & Häuptle, 2006). Also a greater self-direction in the learning process (cf. Schulz-Zander, 2005) and a higher cognitive complexity was determined (cf. Grafe, 2008). But one important finding was, that if teachers have undergone training before using digital media, a greater positiv influence on student performance is shown (cf. Hillmayr et al., 2017).
Based on this studies, it is not surprising that the educational policy of various countries demands, that digital learningmedia should be introduced in schools and universities.
The general digitisation in society also means that parents, students, teachers and other stakeholders expect digital mediato be used in learning. This was only reinforced by the covid-19 pandemic.

How can digital media change teaching?

Organisation

- Tablets/laptops in the classroom
- Learning-management software (moodle,…)
- Interactive whiteboard
- Cooperative software (Answergarden, Padlet,…)
- …

Learning material

- Interactive digital books
- Presentation tools (Powerpoint, Keynote)
- Audios
- Games/Quizzes/…
- Videos
- …

This are just some of the digital media around today. Based on the innovation speed, new digital media will be developed and will change teaching again.

Potential and Challenges

New learning methods and concepts can be implemented in science class, for example flipped classroom. New learning media for example explanatory videos, online courses and online resources can support students' learning and can lead to individual and adaptive learning in heterogeneous groups. The digital exchange of knowledge, media and concepts can improve learning broadly.
But of cource, there are some challanges, that needs to be faced. Digital media are expensive and based on the general innovation, after a few years, it will be difficult to work with some devices. To use digital media successfully in teaching, educators need knowledge and suitable beliefs regarding digital media. Further, a society, that has a negative attitude regarding digital media in school can be a challenge.

Limitation

There is no fundamental superiority in the learning success, if student learn digital. Here too, as has always been the case, it is the didactic concept that is crucial for a successful students' learning. There are new possibilities, but they need to be used effectively by teachers and learners.

Experience and discuss examples of digital media

With the provided material you have the opportunity to get to experience some ideas of teaching with digital media, like:

- Learning with Tablets/iPads – Apps
- Interactive whiteboard
- Online tools
- Digital media in school
- Digital learning environments

Discuss in your team: How can you implement digital media in your science teacher education?

Possible adaptation to the local context

All materials for the ESTA course are adapted and uploaded in E-portfolio:

https://drive.google.com/drive/u/2/folders/1FKt5vRTqfMmrMtdZPCKLYu8vXIqRjBK9

Lilu's House was tranlated into Georgian language and adapted to the local context.

https://www.science-on-stage.eu/material/lilus-house