Evaluation of the results

The overall aim of the RiTE-project is to promote and facilitate (student) teachers to create an evidence-informed teaching practice in science, technology, engineering and mathematics (STEM) education. In one output (O1) partners implement evidence-informed teaching practices in their respective contexts. The Case Studies are available on the RiTE website www.rite-project.eu. The case studies have also been evaluated in output two (O2). This document contains an executive summary of the results. The full findings will be published in due times in the full report and journal submissions.

In this project, several rather different ITE contexts were included. This was done intentionally, and by choosing a common framework in Breckon and Dodson's evidence-use mechanisms and Engeström's expansive learning cycle, we were able to infer some general conclusions. Nevertheless, the project as a whole was very much influenced by the different site contexts. In Groningen, PhD students are employed by the university. They often are very specialist in their specific subjects. This provides a different context for 'teacher education' to students embedded in, for example, Master courses for Chemistry and Biology, as in Poznan and Paderborn. Similarly, a postgraduate year after a degree in the United Kingdom (Chester and Southampton) can only be seen in the context of national teacher education provision, which has been subject to various reforms. Each of the countries has different systems for teacher education, at different levels, with different accountability structures. Of course, the Covid pandemic and the governments' various responses to this came on top of that.

Besides these differences through local contexts, the RiTE interventions show impact on students competence, beliefs and actual implementation of evidence-based practice (c.f. quantitative data). Even if a high growth in competence in Evidence-Based Practices (EBP) can be monitored through a standardised measurement, the initial level seems to be low. Compared to the maximum of points in the test used, students reached approx. 37.6% in the pre-test and 60.3% within post-test. This might link to their perception of preparation through university. Within the interviews students state that they feel prepared by university, but mostly link this to the intervention. Within their prior study program, participants had seldomly reflected the notion of evidence, or evidence-based practice. At this point, the explicit reflection of EPB within the interventions could be helpful to build a mutual understanding what evidence is and in what way it could be important for school. This refers to the evidence-use mechanism of awareness. The role of evidence in daily life and work life got more important for participants throughout the project. Especially phase two of the RiTE project seems to have impact on this. While participants had to think about situations for EBP in school within the post-interview of phase one, within phase two it more or less was challenging to find areas in school, where evidence is not important. This might show a growing perceived importance of the concept of EBP.

This aspect might be linked to the Breckon and Dodson mechanism of agree. While there was no item in the pre-questionnaire which asked participants for their perception of evidence, within the intervention it could be observed, that participants hold a simplistic understanding of evidence. It was hard for them to come up with a definition of evidence. This seems to change through the intervention. Within the post-interview of phase one and the interviews in phase two, participants could describe some crucial aspects about evidence and evidence-based practice. However, they sometimes got uncertain when it comes to the distinction of evidence and opinion. Referring to the specific context, they sometimes accept personal opinions as evidence-like and sometimes show a clear distinction. For the participants in Paderborn this was linked to the field in question. Whenever participants searched for scientific content knowledge, evidence had to be published, reviewed, etc. If they search for evidence regarding classroom practice, they tend to rely on opinions and hints from experienced teachers. In addition to the awareness mechanism, participants seem to feel a need for external hedging of their

decisions and actions. Depending on the context, this could be done by evidence, or hints from colleagues. This described need for external approval seems to target a central aspect of evidence-based practice in connection to the mechanisms of awareness and agree. Within the RiTE-definition of evidence, published research from science as well as experts and practitioners can be counted as evidence. This may allow to trust on the experience of colleagues. However, published research would count as higher quality evidence, because it derives from systematic research. Within the definition, evidence was described as the best available information. In this sense, evidence from research should be preferred and supplemented by expert or practitioners views. Applied to the expansive learning cycle this may refer to the step of questioning. The RiTE partners agreed to draw special attention to the questioning step within the cycle. The reflective nature of this step seems to fit the mechanisms of agree and awareness quite well.

What might be surprising within the results is the low level of actual implementation of evidence and EBP in the daily practice of participants. This especially challenges the perceived importance of evidence within the awareness and agree mechanisms. The question, why participants implement EBP that little, even if they think it is important could not be answered through this study. Though, there might be some perspectives which should get investigated in more detail. At first, participants stated some institutional constraints. Mostly, time seems to be a limiting factor. Participants declared EBP as time-consuming. Doing a sufficient literature review and adapt the found evidence for the specific classroom might be challenging while teaching in school. Even when students get in touch with EBP (e.g. through a research in the internet, etc.), some time is needed. So this constraint refers to using EBP as a teacher and get students to use EBP in their lessons. Participants stated a need of translated evidence. Evidence should be as concrete as possible for practical implementation. Maybe the process of a review is a crucial part of EBP competence. Here, the interest of teachers (simple, translated evidence), scientists (high-quality research) and science-communicators (mediating between those) may clash. While time-issues seem to be a well-known problem of any additional practice in school, participants talked about another reason implicitly in the interviews: hierarchy. As a beginning teacher, or even within in-service training, participants are confronted with the hierarchy in school. In some contexts, participants are dependent on their mentors (especially within in-service training, where participants have to take an exam). In these cases, they may rely on hints they get from their mentors, even if they do not feel comfortable with it. Even the beliefs regarding EBP of the mentors might have influence on the actual practice of the participants. In other cases, articles (especially when they are peer-reviewed, etc.) serve as authorities. Students will incorporate evidence from articles and authors, no matter how trustworthy they may be. An argument of the students is that published research and especially peer-reviewed articles are evidence just because they are published. However, it is important to critically reflect the evidence within articles, etc. These might be some directions for further research regarding the mechanisms of access and communication, interact, skills and structure and process.

Moreover, the concept of certainty/uncertainty seems to have relevant influence within many mechanisms. A notion of evidence as uncertain, like it is conceptualized through research in epistemology, causes many problems. A first problem might be the teaching of evidence-based practice. Teachers have to give some orientation and information on evidence while dealing with the notion of uncertainty themselves. How should students trust this information, if the take-home message is: Evidence is uncertain. Herein, the role of trust becomes crucial. Students should trust in teachers, who teach them to not trust in evidence, because it is uncertain. There seems to be a necessity for balance of thoughts. Some evidence must be trusted, because otherwise no thinking is possible. Sometime new uncertainties derive from former certain processes (e.g. expansive learning cycle). However, this evidence should not be trusted regardless of any critique. The notion of uncertainty was reflected within the interviews of a few participants. They found it challenging to teach evidence as uncertain, because they fear, students expect them to know everything they process in the classroom. This could lead to general incredibility of the teacher, or the content knowledge derived from decades of research. In

consequence, the balance of certainty and uncertainty is important, especially in relation to reasoning of evidence. For specific evidence, there might be good reasons to take it as certain, or uncertain knowledge. This aspect links up with authorities in evidence (see above) and research in the field of epistemology.

Compared to the field of evidence-based medicine, a question could be, whether standard procedures as they are known in health care could also work for education. However, the health system differs from our educational system. One the one hand, within medicine medical doctors create research for medical doctors. In the field of education, research is done by science educators for teachers. This creates differences even in the field of authority and trustworthiness. On the other hand, in medical research, there are high-quality evidences. One could do randomized, double blinded control group studies, while in education it is very hard to control some variables. At least, medical research has much more funding than educational research. These differences show the necessity of the development of evidence-based education as an independent field, which may be oriented to evidence-based medicine.

Recommendations to the public

What kind of recommendations could the RiTE-consortium give after the project?

The first and maybe most important one would be: **“Create more time for reflection”.** Even when participants did not know the term evidence, they could think about the concept and discuss some important points. Reflecting the way on what basis one decides about actual classroom actions is possible, even without the term ‘evidence’. Therefore, some conceptual aspects of evidence can be discussed with the participants, even if they are not familiar with the concept of evidence by itself. Within their study program they mostly did not realize that they actually worked with evidence. Asked about that, they could reflect that they actually used evidence-based practice. Time slots need to be offered to students to think and reflect about their own practice. This recommendation is in line with the theoretical background of this study (especially: Breckon & Dodson, 2016; Engeström, 2001).

A next recommendation is closely linked to the first one: **“Bring together the practice of research and teaching”**. A research approach to the own teaching may lead to critical reflection, evaluation and innovation in teaching. While a teaching approach to research may lead to applied evidence, research on the basis of realistic classroom actions and better communication of evidence. Both practices could inform each other. As can be modeled through activity theory (c.f. chapter 2.3), both practices have specific rules, skills needed, etc. However, they (in the case of educational research) have the same objection: strengthen the competence of students. Participants often stated things like: “I’m not a researcher. Why do I have to do this?”. One assignment of EBP interventions should be, to make this clear. Why is it important for teachers to be competent in research? Why should educational researchers have insights into actual teaching and classroom action? If these connections get clarified, the gap between educational research and educational practice (like it is absent in health care) might be overcome. The question then is, who could teach that kind of EBP for education? We need more 'brokers' at the interface of research and practice. But the challenge is they need to be experts at understanding research AND have frontline classroom experience. This would be another recommendation but also challenge at the same time. Nevertheless, working from a common frame (Breckon & Dodson, 2016) and sharing experiences and data could also raise awareness.

Moreover, it is important to clarify the role of authority. So another recommendation would be: **“Support trainees in developing a critical attitude towards the research process and results described in articles, instead of only 'trust' in the authority of certain researchers, journals, etc.”**. Students should not just believe in authorities. Especially in times of fake news and alternative facts, the concept of authority might be risky. There will be an authority for nearly every opinion or statement. It really is

important to think about the evidence, which is brought up by them. What are personal interests of the authorities? To what extent is high quality research incorporated in the statement? It is the same for research articles. Students should get encouraged to reflect evidence critically. They should rely on their own thoughts regarding the presented evidence. This, for sure, requires knowledge and competence in EBP, however, it is worth the effort to enhance this competence.

From a scientific perspective, our recommendation for research regarding EBP would be, to use interviews as (one) method. Especially the interviews gave important insights into the beliefs and competence in EBP. Many aspects, which could be found in the questionnaire and scales got even more clear within the interviews.

The maybe most important recommendation would be: **"There is no one-size-fits-all"** when it comes to learning about EBP and evidence. Even within the RiTE project, many contextual differences occurred. On the one hand, this might not be surprising. Different countries have different educational systems and policies. Differences may therefore be inherent within the design of the project. On the other hand, all project partners base their work on a shared theoretical framework. Even within this framework there were different focuses within the specific contexts. However, the framework allowed the partners to align their interventions. Especially the evidence-use mechanisms (Breckon & Dodson, 2016) were found to be helpful. They gave orientation while planning the interventions and served as shared vocabulary. They allowed to bring specific aspects of the local contexts down to a common baseline to discuss these aspects.

All in all, the main recommendation is: Reflect on evidence and evidence-based practice. Even if the concept of evidence might seem vague at first, it is worth elaborating on it. It enables people to argue independently and evaluate others opinions. Moreover, it may have influence on their own teaching practice and everyday life. Evidence-use mechanisms might give orientation in the field of evidence and uncertainty. They even allow to evaluate ones own perspective on evidence.

Note: for contact with the project team, please visit the website www.rite-project.eu.