

StudyBase

Planning and Pre-registration Form

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This template is modified from Kern et al. (2017) and a template for pre-registration on OSF (OSF Prereg, <https://osf.io/zab38/wiki/home/?view>). It has been adapted and expanded to allow the preregistration and documentation of educational design and improvement studies across the phases of context analysis, design, implementation, efficacy, and spread.

General information

| | |
|--|--|
| Study title | Student and pre-service biology teacher conceptions of the role of organismal agency in evolutionary adaptations |
| Lead researchers and collaborators with affiliations; Contact information | Susan Hanisch Dustin Eirdosh ... |
| Abstract | Describe in a short paragraph the aims, context, methods, and expected outputs of your study. |
| Field Site name | What is the name of the school(s)/institution(s) or the community where you will conduct your study (leave empty if this should be kept anonymous). Friedrich-Schiller-University of Jena |
| Country(s) | Germany; ... |
| Region(s) | |
| Rural, urban | <input type="checkbox"/> rural <input type="checkbox"/> periurban <input checked="" type="checkbox"/> urban |
| Project start date | October 2022 |
| Estimated project end date | February 2023 |

Type of study

What phase(s) of the educational design and improvement research process does this study cover?

- Context analysis**
- (Research) Methods development**
- Design of improvement strategies/interventions/tools/processes**
- Implementation of improvement strategies/interventions/tools/processes**
- Studies on outcomes/efficacy of interventions**
- Spread, integration, adaptation of innovations within and across contexts**
- Theory development, synthesis**

Related studies

List here and link to any previous or ongoing studies that are related to this study, such as studies on other phases of the research process, or case studies in other contexts.

School Portrait themes

What themes of the school portrait will your study address (regarding understanding, improvement)?

- School History**
- School Futures**
- Demographics & Infrastructure**
- School Curriculum**
- School Governance**

- School Culture & Wellbeing**
- School Ecology**
- School in Society**
- Community Science Lab development**

Theoretical context

In this section, describe the theoretical context in which the research is being developed

Darwin's theory of evolution emerged from his deep contemplation regarding the role of organismal agencies in the development of adaptive forms over generations. Modern synthesis approaches to evolutionary biology, adopting narrowly gene-centric perspectives, tend to abstract out, or even refute the role of such agencies in evolutionary change. Evolution education, having been developed largely in the mold such narrow gene-centrism, tends to view agency as a concept that is not apart of, or even antithetical to, the central learning target of the field. In this work, we question that assumption, and explore student conceptions of agency as it relates to expert evolutionary reasoning across five diverse case studies. We view this work as a first step in laying a foundational understanding of student and pre-service teacher conceptions for evolutionary reasoning that adequately accounts for the role of preferences, goals, and behaviors of organisms in adaptive change.

Research aims, questions, hypotheses

In this section, list the question(s) that your study aims to answer. The kinds of questions usually depend on the phase that the educational design research study is in (see above). Below are example research questions for each phase. If applicable, list also any hypotheses that this study aims to test (confirmatory studies; efficacy studies) or generate (exploratory studies, implementation studies).

Context analyses

- How do high school students and pre-service biology teacher students conceptualize the role of organism preferences, goals, and behaviors across a range of scenarios of evolutionary adaptation?
- How does student reasoning about the role of organism preferences, goals, and behaviors in evolution relate to their responses in standard evolution assessment items?
- How does student reasoning about the role of organism preferences, goals, and behaviors relate to their history of learning and subjective expertise in evolution?

(Research) Methods development

- Can open-ended prompts on the role of organism preferences, goals, and behaviors in evolutionary adaptation elicit pedagogically useful student responses?
- What coding system can best structure the analysis of student explanations regarding the role of organism preferences, goals, and behaviors in evolutionary adaptation?

Theory development

- Can explicit reasoning about the role of organismal agency in evolutionary adaptation provide a stepping stone for the development of scientifically adequate and metacognitive understandings of evolutionary change?

Study Design

Descriptive study - Data is collected from study subjects that are not randomly assigned to a treatment. This includes surveys, natural experiments, case studies.

Quasi-experimental design - There are treatment and possibly control groups but subjects are not randomly assigned (common in educational contexts); pre-post designs, longitudinal designs.

Experiment, RCT - A researcher randomly assigns treatments to study subjects to assess if an intervention results in expected outcomes.

Descriptive study with the help of a survey method

Study Participants / Stakeholders

Describe the types and numbers of participants that will be involved in your study and from which you plan to collect data. How will you decide who to include? Describe the sampling procedure - the population from which you obtain subjects, the criteria and methods for selecting the group, recruitment efforts, payment for participation etc. Include any recruitment information and participant consent forms in the Appendix or as a link. Describe the sample size of your study. How many units will be analyzed in the study? This could be the number of individuals, teams, classrooms, schools. If you are using a clustered or multilevel design, how many units are you collecting at each level of the analysis? (e.g. "four units at the level of classrooms within a school"). Explain the rationale for the sample size (this may often be determined by the pre-existing size and structure of the study group, or time and resource constraints).

[N] Pre-service biology teachers at FSU Jena in the X semester of their study program
Convenience sampling based on research partnerships of the researcher team

...

Intervention Design and Implementation

If it is a design, implementation or efficacy study, describe the intervention you are designing or implementing. Include any curricula and similar more detailed information on the intervention in the

Appendix or as a link, or refer to previous studies that describe the intervention. Who will be implementing the intervention, what roles do practitioners, study participants, and researchers play? What is the time schedule of the intervention?

We have developed a novel instrument for eliciting student conceptions regarding the role of organismal agency in evolutionary outcomes. We have selected five diverse case studies (Cheetah's speed, Peacock's feathers, Snail's shell, Cacti leaves, Upright walking in humans) on the basis of representing a range of possibilities within the space of internal-external agential influence on processes of natural selection. Engaging short briefs on each case study, students select all scientifically adequate explanations and open ended responses focused on the relations, if any, between the preferences, goals, and behaviors of organisms, and the evolutionary outcomes of the case. Some items are building on the KAEVO 2.0 (Kuschmierz et al. 2020), however the direct and explicit focus on the role of agency in evolutionary outcomes is unique as far as we know, and may shed further light on the interpretability of KAEVO 2.0 items.

Our research team includes biology teacher education faculty in Germany, Argentina, [and Brazil]. Pre-service biology teachers will engage the instrument as part of their normal experience within their respective training programs.

The instrument is expected to take 25-30 mins to complete.

Local biology education research groups will debrief students following their engagement with the instrument, introducing conceptual tools (e.g. causal mapping; 'The Triad') for reasoning about agency in evolution.

Data and data collection methods

Describe the kinds of data you aim to collect and the methods of data collection. In educational design and improvement research, data usually includes quantitative as well as qualitative data, and methods usually include literature reviews, surveys, interviews, observation and field notes, artifacts, photos, video. Specific data collection tools such as interview protocols or survey questions can be listed in the Appendix or linked here. Describe if and how you will be piloting your methods.

Data and variables: describe the kind of data, variables and/or constructs

- Demographic information on experience and subjective level of understanding of evolution
- Quantitative data: responses on multiple-choice questions
- Qualitative data: responses on open-ended questions

Data collection methods and protocols:

- [Questionnaire protocol](#)

- Vignettes of the evolution of traits, partly adapted from KAEVO 2.0 (Kuschmierz et al. 2020), spanning cases of adaptation variously driven by organism agency as well as spanning different species and trait types ([see codings in our case study database](#))
 - Cheetah running speed (KAEVO 2.0)
 - Peacock feathers
 - Banded snail (KAEVO 2.0)
 - Cactus leaves (KAEVO 2.0)
 - Upright walking of humans
- Multiple choice questions (based on KAEVO 2.0)
- Open-ended questions:
 - What role, if any at all, did the preferences, goals, or behaviors of [focal organism] ancestors have in the evolution of [focal trait]?
 - What role, if any at all, did the preferences, goals, or behaviors of other organisms in the [focal organism's] environment have in the evolution of [focal trait]?

Data collection tools: How will you actually collect the data?

- Moodle questionnaires,

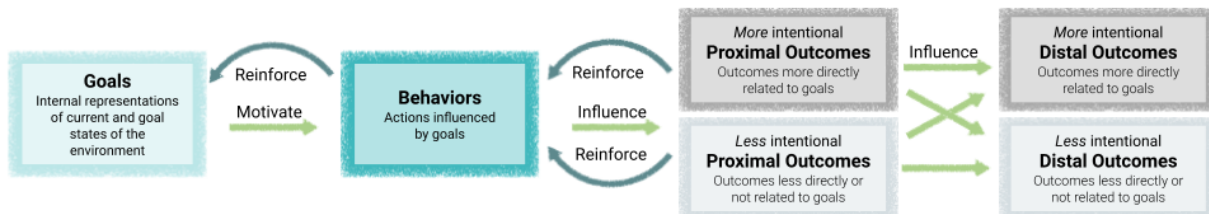
Data analysis methods

Please describe the analytical procedures and tools you will use to analyze your data. Add coding schemes or other further details about analysis in the Appendix.

- Between subjects and countries:
 - Descriptive statistics of quantitative assessment items (multiple choice questions), accuracy of responses
 - Within and between country samples
 - Qualitative content analysis of open-ended questions
 - Adequate framing of the role of agency vs. misconceptions
 - Deductive: relations between goals and outcomes (see fig.1 below)
 - Inductive category formation
 - Level of completeness and detail vs. ambiguity and superficial language
 - Inductive category formation
- Within-subjects and between subjects and countries:
 - Degree of qualitative differences between vignettes
 - Correlational analysis between multiple choice and open-ended responses
 - Multiple choice accuracy <> explanatory adequacy

- History of learning evolution <> accuracy & adequacy
 - Inductive category formation: typologies of subjects based on quantitative and qualitative responses

Fig 1. A schematic representation of categories and relations of interest in evolutionary explanations:



Reporting, Sharing, and Outputs

Please indicate the type and number of outputs and publications planned for this study. Will the data collected in this study be shared with others, and if so, with whom and in what form?

All materials and anonymized data will be made available on the OpenEvo website.

A manuscript will be prepared for publication in a peer-reviewed educational research journal.

Target journal(s):

Evolution Education & Outreach (EEO) / Journal of Biological Education (JBE)

Other outputs:

- **Methods development:** This study will contribute to the improvement of assessment methods for characterizing and evaluating student conceptions of agency in evolution
- **Theory development:** This study will contribute to design-based interventions for engaging students and pre-service teachers in reasoning about the role of agency in evolution
- **Teacher development:** This study will inform the development of an online workshop for biology educators on understanding the role of agency in evolution

Partners, Collaborators, Funding

If applicable, please name the source of funding for your project.

If applicable, please name the institutions or organizations collaborating with you on the project

No external funding has been received. All local data collection is in-kind from the respective biology teacher education research groups.

Has this research received approval from an Institutional Review Board (IRB) or ethical board?

No - not required

If yes, please name date and institution of approval

Certification

I hereby register my research project and supplementary materials. I confirm that I own the rights to release these materials into the public domain.

References

Kern, F. G., & Gleditsch, K. S. (2017). Exploring Pre-Registration and Pre-Analysis Plans for Qualitative Inference. Pre-Print, 1–15. <https://doi.org/10.13140/RG.2.2.14428.69769>

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Appendices

Including more detailed intervention plans and materials, data collection tools, participant consent forms etc.

Participant consent form