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Teaching Science Communication

Experiences from Psychology

ABSTRACT

Communicating scientific findings to the general public is an important part of universities' third mission. While the need for communicating research is amounting, university graduates hardly receive any training and are thus not well prepared to meet this challenge, be it as a researcher (e. g. during a PhD) or in the applied field of their studies. To address this gap, I have incorporated science communication training into my teaching and developed dedicated science communication courses for Psychology students. This paper focuses on a course on "Communicating Findings from Developmental Psychology" at Masters' level, which I taught at Heidelberg University during the summer semester of 2022, and is replenished with experiences from a general course on "Science Communication" at Bachelor's level taught during winter 2022/23. Experiences document that students are interested in communicating scientific findings, and eager to develop their skills for this important task. Course structure, experiences and outcomes are documented, and slides as well as science communication outputs are shared via an open science platform.

Keywords: Science Communication – Psychology – Course Development

ZUSAMMENFASSUNG

Wissenschaftskommunikation ist ein wichtiger Teil der gegenwärtigen universitären „Dritten Mission". Doch obwohl Wissenschaftskommunikation zunehmend gefordert wird, erhalten Studierende kaum Training, das sie auf diese herausfordernde Aufgabe in der Wissenschaft oder dem außeruniversitären Arbeitsumfeld vorbereitet. Um dieser Lücke zu begegnen, beziehe ich Kommunikationsprojekte in meine Lehre mit ein und habe Wissenschaftskommunikationskurse für Psychologie-Studierende entwickelt. Dieses Paper legt einen Fokus auf einen Master-Kurs zum Thema „Befunde aus der Entwicklungspsychologie kommunizieren" der im Sommersemester 2022 stattfand, und beschreibt ergänzend Erfahrungen aus einem Bachelor-Kurs „Wissenschaftskommunikation" aus dem Wintersemester 2022/23. Die Erfahrungen aus diesen Kursen zeigen, dass Studierende großes Interesse daran haben, wissenschaftliche Erkenntnisse zu kommunizieren, und ihre eigenen Fähigkeiten dazu engagiert weiterentwickeln. Die Kursstruktur, Erfahrungen und Ergebnisse werden diskutiert, und Folien sowie Kommunikationsprodukte über die Plattform open science framework bereitgestellt.

Schlagworte: Wissenschaftskommunikation – Psychologie – Kursentwicklung

Introduction

Locked in the "ivory tower" or connected to our world? With digital evolution, researchers all around the globe have increasing opportunities to leave their ivory tower and connect with society. This is a timely development, as humanity is not only confronted with immense, world-wide crises like war and climate change, but also with technological advancements that increase the likelihood of fake news (ALLCOTT & GENTZKOW 2017). Thanks to social media, individuals are able to address others anywhere in the world with messages that are more direct, personal and more quickly delivered than ever before. Therefore, the time is ripe for researchers to take their chance and communicate scientific findings to target audiences outside of their own field of research.

While the need for scientists to communicate about their research is obvious, researchers face many obstacles on their path out of the ivory tower. The main tasks of performing research and teaching students naturally consume most of the available time, potentially hindering many of us from communicating what we have to say to new audiences beyond academia. Moreover, science communication is hardly acknowledged within the community, and contributes little to employment success within the field. However, even if we are intrinsically motivated and want to take the time for science communication, hardly any of us have received training on how to do this. We therefore face questions such as where do we start, why should we communicate our science, where can we find our audience, and what should we say?

As a PhD student, I stumbled across an online science communication initiative in Psychology, "de.in-mind.org". I was highly motivated to join and did so, but faced exactly the questions noted above. Learning-by-doing and taking as many courses as I could find, I have scrambled to develop my skills in science communication. Very early on I realized that for science communication, the same dictum holds true as for all topics at the university: research and teaching should go hand in hand and fuel each other. Incorporating science communication into my teaching is advantageous both for my students and for me, as it helps us all to develop skills and grow into our roles as communicators. In teaching, I am required to clarify my knowledge about and understanding of science communication; on the other side, students can develop an understanding of their role as communicators and develop their skills. Some students will become the next generation of researchers, and we can take much more influence by preparing them for communicating their science to society than by just communicating on our own. I am also convinced that also teaching those students about science communication who will not stay in science is of great consequence, as they are the ones who will truly leave the ivory tower and are thus invaluable messengers for enculturating science in our society.

Based on my own experiences in communicating science and in supporting students to develop skills in science communication, I have developed courses at Bachelor's and at Master's level aiming to foster Psychology students' ability to communicate self-selected research findings to target audiences. While the term "science communication" can also be

used to refer to communication within the own scientific community, in this article it is employed for communication acts directed towards people outside the own scientific discipline ("external" science communication, NIEMANN, SCHRÖGEL, & HAUSER 2017).

In the following, course outlines will be illustrated and teaching/learning experiences made in these courses will be discussed, with a focus on generalizable inferences. The article concludes with future directions and propositions for teaching science communication across disciplines.

General Ideas for Science Communication Courses

If we want to train students in science communication, in my view top-down (e. g., research on guidelines for effective communication) and bottom-up approaches (e. g., experiences of students communicating with their friends and family) can be differentiated. From my experience, it can be recommended to incorporate both approaches by teaching general guidelines, applying them to specific scientific topics, and having students try them out in practical exercises. It follows from this approach that the general teaching and learning methods employed here may be beneficial in many disciplines, but the application part of this course is specific to psychology. Good practice samples, interactive exercises and feedback seem key elements useful for developing science communication skills (SILVA & BULTITUDE 2009). In particular, a survey with trainers and trainees has identified a number of best practices in science communication training (SILVA & BULTITUDE 2009: 8):

- Style: interactive; bespoke to group
- Activities: demonstration → performance → feedback; practice at live event
- Topics: reflection/discussion of learning outcomes
- People: interaction with peers that do science communication, more than one trainer

The courses described here incorporated many of these aspects and will be discussed in more detail in the following paragraphs. In summary, the style was interactive and largely adapted to the participants' interests and needs; demonstrations of adequate science communication were given before students were required to communicate themselves; feedback was given repeatedly; learning outcomes were discussed at the end of the semester. Practice at a live event was not possible in the current setup, as was interaction with science communicator peers or more than one trainer. These aspects could be incorporated into a broader science communication syllabus in the future.

Course Outlines

First, an overview of the course "Findings from Developmental Psychology for Application" is given, before individual sessions are described in the next paragraphs. This course was newly developed and implemented during the summer term 2022 within the established Masters curriculum for Developmental and Clinical Psychology as "application-oriented course" ("Anwendungsorientierte Vertiefung"), and was equivalent to 4 credit points (2 SWS). The number of students was limited to 15 due to the intense nature of the course, involving teacher feedback loops at different points throughout the semester.

General guidelines I adhered to while developing this course were:

1. *Definition of learning objectives*
   On the basis of the Bloom's taxonomy (1973), cognitive achievements and/or competencies that students should reach by the end of this course were defined.

2. *Constructive Alignment*
   Following the principle of constructive alignment, learning objectives, sessions' content, teaching and learning activities, and assessment procedures were coordinated (Biggs & Tang 2011).

3. *Sandwich-Principle*
   The course was designed to follow the sandwich-principle, in which teachers' input and students' activity phases are alternated (Land Baden-Württemberg 2020). The student activity phases consist of individual (e. g., preparing an individual science communication course work) and collective student activities (e. g., role play, interactive feedback for each student's course work).

4. *Individual contributions by students*
   The content and form of each course project was chosen by the respective student. In accordance with self-determination theory (Ryan & Deci 2000), taking decisions autonomously, albeit based on social discourse, enhances students' motivation.

5. *Generating appropriate learning material (design of slides and other input material, pin-pointing each session's content)*
   Several recommendations can be made regarding the design of learning materials based on research. First, in accord with dual coding theory (Clark & Paivio 1991) and the picture superiority effect (Hockley 2008), learning material was prepared so that visual information supported content provided orally. Findings from short term memory research (Cowan 2010) suggest that the number of chunks forming one content should be tailored to 3–7 (e. g., bullet points on a powerpoint slide). Based on current models

of working memory (BADDELEY 2010), processing of spoken rather than written language requires less effort, so text on the slides was curtailed. Moreover, visual cues were provided by designing diversified slides to facilitate recall of content. Still, based on cognitive load theory (VAN MERRIËNBOER & SWELLER 2005), learning material was kept as simplistic as possible to prevent style from distracting students from the classes' content. Together, designing learning material in these ways can support student learning.

In congruency with the module handbook, the following content was taught:

How to communicate scientific content to laypeople:

- How to adjust communication means to target audiences
- Communicating understandably – spoken language, writing, graphics and X (any potential other channels)
- Reflecting on and receiving feedback regarding science communication
- Analysis and supervision of counseling with developmental populations
- Practically relevant topics from developmental psychology

The learning objectives of this course were defined as follows:

- Students are able to
- Identify and process practically relevant scientific findings from developmental psychology
- Evaluate the comprehensibility and appropriateness of science communication outputs
- Communicate findings from developmental psychology in a customized and well comprehensible way
- Frame counseling situations with families appropriately and reflect one's own communication patterns

The requirements for successfully finishing this course were:

- Actively participating in the meetings
- Preparing and performing a practical course work, potentially (but not limited to):
    - A session of advanced training for childcare professionals
    - A counseling session for parents
    - A Youtube video, podcast or science communication article with content from Developmental Psychology
- Reflection on this practical course work (approx. 8-10 pages)
    - Theoretical part/introduction
    - Documentation of planning and preparations
    - Documentation of executing the practical course work
    - Critical reflection

Sessions Planned

The seminar was planned with weekly sessions, some of which were dedicated to preparation and feedback (no group meetings). In Table 1 (appendix), an overview of all sessions can be found.

The first session provided the general course guidelines as well as an introduction to science communication. During the second session, students were aided in their search for content that they would like to communicate, and handed in written proposals. They received feedback for their proposals to help them select and devise a topics. The following weeks were dedicated to different science communication formats, including written articles, verbal communication, and counseling. Interspersed were sessions for developing the student communication projects, including individualized feedback sessions with the teacher. These were complemented by a session on research about science communication, to provide students with a scientific basis for their communication efforts. The second part of the course consisted of sessions in which students presented their science communication products, illustrated the reasoning and processes behind their projects, and were given interactive feedback. At the end of the course, each student handed in their final product as well as a written reflection of their science communication project. The course ended with a group reflection session.

Implementation

During the summer term 2022, four female students at Masters' level enrolled for this course. Students participating in the course voiced surprise at the low participation rate, which was attributed to time-overlap with other important courses, and affirmed that informal discussions revealed their fellow students' interest in the courses' topics. Furthermore, student engagement and commitment during this course confirms their high interest and involvement with questions of how to communicate research findings to target audiences. On the other hand, I invited all students of the Psychological Institute to apply for mentorship in science communication in spring 2022, aside from their official study curriculum. Without the option of receiving credit points for communicating science, no student applied. It therefore seems that interest in the topic is high, but students are mostly willing to engage if it fits well into their schedule and they are rewarded with course credit. Due to the small group, the semester plan was partly adjusted (cf. Table 1). First, fewer sessions were needed for individual councelling on their respective projects, and second, each student was able to present in an individual session, facilitating deep exchange on each course work. Moreover, as three individuals were sick during the weeks dedicated to "Case Studies" and "Science Communication Research", these sessions were combined with the "Review and Reflection" session at the end of the semester. Finally, it was not possible to employ the general teaching evaluation form of Heidelberg University's quality management, as evaluation is

supported only for courses of 5 or more participants. Therefore, the dartboard method and a classroom discussion were employed to receive feedback on this course (cf. Table 1). The feedback is illustrated in "Course Reflection".

Experiences during course implementation

An overview of course experiences detailed by session can be found in Table 2. During the first session, students' prior experiences with and knowledge about science communication were explored. Students could well identify examples of science communication, but had relatively little practical experience with topics from developmental psychology that might be relevant for science communication. Moreover, they voiced some concern regarding the project character of the seminar, being unsure about what to expect and what was expected from them (while being excited by these possibilities at the same time). Despite these initial concerns, the first collection of potential topics was very goal-oriented and fruitful. This can be verified by comparing proposals to final products: All four topics proposed within the first two weeks were implemented as products and all employed the science communication method proposed, but all were later refined in terms of sub-topics, central themes, and design/layout. The teacher provided feedback regarding the suitability of proposed topics and formats, which were all excellent, as well as potential challenges, further sub-topics and open questions.

The third session was devoted to university didactics to enable students for communicating science in the form of training in professional development. A verbal survey on students' experiences in higher education provided a basis for deducing guidelines. All students reported enjoying courses where they could actively participate, the teachers seemed inspired, and individual topics could be selected. They described that exchange with the other students was very valuable, but that teachers should nonetheless add information to what is discussed among students. These individual experiences could be well aligned with the prepared input on university didactics. In the session on counseling, students indicated very little prior experience, and relatively poor knowdledge of general guidelines. The input was supplemented with an exercise on video-based interaction counseling, which students considered important in particular regarding the identification of appropriate behavior examples and positive feedback.

After approximately half the semester, individualized mentoring sessions were offered where each student presented the status quo of their course work to the teacher. Each course work was very well developed. Thirty minutes sessions were sufficient (in presence or online), plus written feedback for course works that worked with visualizations (e. g., slides or flyers). For support, the teacher provided additional references/resources, questioned the target group and main/secondary messages, and mostly gave tipps for implementation (scope/extent of the content, visual design and comprehensibility of content).

At the end of the semester, students presented their projects of science communication and/or counseling. A flipped classroom format was chosen when appropriate, moving the knowledge input to the preparation at home, e. g. via flyers, booklets and podcasts. Live sessions focused on embedding the science communication project (why were selections made, what reasoning stood behind decisions taken) and feedback from the group. It was agreed that contents were selected appropriately and were well tailored to the target groups. However, the outputs were partly deemed too dense/included too much information. In some cases, the language was deemed too demanding. Students were instructed to address these constructive comments in their final product/their written reflection.

Due to sickness of several participants, two sessions had to be postponed, a downside to the overall warm atmosphere of this very small course. The feedback process in the last session indicated that all students considered methods and topics as highly relevant and interesting, and valued the independence granted to them in this course. Moreover, students rated their ability to transfer knowledge from this course to their work as a psychologist as excellent. However, the work load was considered appropriate to a little high; students estimated their net-working time towards their own course work between 2-5 full days (~ 16-40 hrs). One student desired more input from the teacher. All agreed that when teaching this course with a larger group, working together on group projects would balance the workload for both students and teacher. The overall positive evaluation was shared by the teacher.

Reflection on Practical Course Work

Students were required to hand in an 8-10 pages reflection of their practical course work two months after completion of this course. A long time-window for preparing their reflection was deemed appropriate to potentially enable further revisions of their course work, to develop a more comprehensive retrospect on the course work and the seminar, and to reflect on feedback provided by others after a longer interval.

The reflections were overall very elaborate and revealed students' deep involvement with their selected topics and formats, as well as the sophisticated design of their course works. Moreover, they all incorporated the group's feedback for their product into their reflection as requested. They were all provided with written feedback for their reflection, containing general (concerning recurring aspects/challenges across reflections) and individualized feedback.

General feedback was provided regarding the following points, which had been verbally communicated beforehand:

— "A reflection should contain the theoretical background of the course work, methods employed, a review of the way from initial ideas to the final course work (what did I think at the beginning, what influenced my decisions in the process, how content am I with the result…) and thoughts on whether feedback from the teacher/the group was useful and whether corresponding changes were/would be implemented if the project would continue. Both strengths and weaknesses of the science communication course work should be discussed." Most aspects appeared in the reflections, but some were left out in some instances.
— "Students are of course most welcome to pick up suggestions by the teacher or the group. However, they do not necessarily have to pick up suggestions, but can decide for themselves if they are useful for their project. In some reflections, it seemed as though students had felt obliged to pick up all suggestions. Another option would have been to list different ways to address an issue, and to state why the own/original approach was selected. Partly, the teacher's arguments were cited as pure facts to argue for changes suggested by the teacher/group, which is an overstatement."
— "For the theoretical part, general recommendations for giving references should be followed (this part should be very similar to theoretical introductions written in other contexts). The focus on science communication course works should not reduce the rigour of the theoretical part."

Individualized feedback emphasized strengths of each course work and pointed out specific aspects that might be improved, mostly instantiations of the general feedback.

Course Reflection

Students in this seminar have developed and documented their ability to connect with parents and childcare professionals for making a transformative use of scientific findings. They independently identified crucial topics of developmental psychology and communicated with potential target groups in very well-tailored and highly individualized ways. All four students developed very interesting and high-quality science communication products, which we are planning to make available for the broad public. In case of the advanced training session for Childcare Professionals, the student and I are planning to continue working on the topic of "Children's endangerment" during her Master's thesis by providing an empirical basis of Childcare Centers' needs in such a course.

Both the students and I as a teacher enjoyed working together during the course and we all furthered our abilities for science communication. The students repeatedly described that

they had relatively little experience with or knowledge about science communication in the three areas targeted in this course (general science communication, counseling, advanced training for child care professionals). Input parts in the course were met with high interest and usually evoked a discussion among all course members. Thanks to the interactive nature of this course, students answered each other's questions appropriately and provided arguments which I otherwise may have given. For instance, during the presentations of each student's science communication project, most feedback regarding the impact and appropriateness was provided by fellow students. Most of the points I would have raised were adequately approached by other students, and were likewise well taken by the respective presenter.

Therefore, as documented by students' reflections, the course's learning objectives were mostly fulfilled:

- Students are able to identify and process practically relevant scientific findings from Developmental Psychology.
- All four students focused on highly relevant topics, identified important scientific findings regarding their topics, and compiled them in a way comprehensible to lay people.
- Evaluate the comprehensibility and appropriateness of science communication products
- All four students provided insightful and helpful feedback to the others' science communication products, reflecting their understanding of and learning regarding well comprehensible and goal-directed science communication.
- Communicate findings from Developmental Psychology in a customized and well comprehensible way
- All four students selected individual communication media that were appropriate for their respective topics, communication goals and target groups. The comprehensibility of their science communication products increased with every round of feedback, reflecting their learning curves. In the finally submitted versions, only minor further refinements facilitating lay people‘s comprehension needed to be recommended.
- Frame counseling situations with families appropriately and reflect their communication patterns
- This topic had been incorporated in the course as I thought it would interest many students. Unexpectedly, none of the students selected to work with counseling situations. Therefore, the course focused on counseling situations only during one session. Students likely learned some basics on framing of and communicating in counseling situations, but this was not deepened in a project or evidenced in any of the reflections.

To sum up, all learning objectives except the goal for framing and communicating in counseling situations were fully met. Likewise, students reported high satisfaction with this course, rated their ability to transfer knowledge from this course to their work as a psychologist as excellent and valued greatly the amount of independence granted to them during the semester. However, one student desired more input from the teacher. I fully agree that a broader basis in science communication would be valuable for developing an even more reflexive and targeted science communication product.

While desirable, providing more input is difficult to incorporate into the current course. Due to the practical nature with multiple feedback loops, increasing the number of input sessions would enhance the workload for the students and the teacher too much.

One option to cope with this dilemma would be to split the course in two parts, stretched over two semesters, to be attended consecutively (optional).

Future Directions

In the following semester (winter term 2022/23), I developed a new course at Bachelor's level on "Science Communication". This course could be conceived as a basis for "Findings from Developmental Psychology for Application" described here. The experiences during this course provide further support for students' overall interest in topics of science communication, and their appreciation of the opportunity to develop communication skills. Here also, the number of participating students was limited to 16 due to the intense nature of feedback provided within the course. 25 Psychology students and numerous students from other disciplines applied, so that several prospective students had to be declined. In the following, the course syllabus is briefly described (cf. Table 3 in the appendix for more overview and details).

The first session with general guidelines and a brief intro to science communication was supplemented by a homework in which students should reflect where and when they get into contact with science communication. Additionally, they had to ask friends and acquaintances how they get into contact with science communication, and which input from Psychology would be of interest for them. The second session included a broader introduction to science communication (who, what, to whom?) and focused on differentiating science communication & science journalism. As a homework, students collected and judged science communication examples from all kinds of media. In the third session, students were assigned into small groups to discuss the collected science communication examples and to derive recommendations for best communication practices. After the session, the teacher developed a comprehensive practical guide including the suggested recommendations as a basis for the whole course.

The next session expanded on principles of felicitous science communication, including to define target audiences, to formulate learning/experience objectives, to develop a broad structure, and run a literature research. Students were then asked to apply the practical guide

to a science communication example and judge its quality. During the fifth session, psychological principles of good communication were discussed. Following an intro, students familiarized themselves with biases and heuristics and presented them to one another in small groups.

The second part of the seminar was more dedicated towards developing one's own communication abilities. In the sixth session, students trained their skills at delivering an elevator pitch and gave each other feedback. In a session on visualizations and statistics, input on psychological research for improving audience's understanding of statistics was supplemented with a group exercise using science communication examples. Next, all participants were required to develop their own communication project by defining their topic, target population, goals and potential challenges. In an online session, coherent writing was practised by interactively formulating short main sentences, reducing nominalizations, employing active and positive sentences, and reducing expletives. During the 10th session, input on guidelines for In-Mind (de.in-mind.org) blog posts and articles was provided, as all students were required to hand in a blog post and an article for course credit. They wrote a first draft of blog post and received individualized feedback from the teacher. All suited contributions were invited to submit a revised version based on teacher's feedback for publication to In-Mind.

In the last sessions, current developments in the field of science communication were addressed. These included dialogic forms of science communication and anchoring science communication in the scientific system, and were largely discursive due to imminent developments. The last session was dedicated to review and feedback, and overall revealed that the course served to maintain students' motivation for communicating science, while providing students with the means for high-quality communication.

When designing the two courses consecutively, the first course ("Science Communication") could focus more on basics/theoretical foundations of science communication, whereas the second course ("Findings from (Developmental) Psychology for Application") could focus more specifically on project-related work, always providing a short reminder on basics taught in the first course. To work on these topics even more comprehensively and transformatively, an extended Science Communication course open to students of all disciplines would be desirable. Working together with students across disciplines would provide opportunities for providing/receiving feedback on science communication projects from people who are non-experts regarding one's own field of study. This way, students and teacher(s) would need to leave their own "bubbles", and both evaluating others' science communication products and communicating to lay people could be trained more effectively. In such a case, it would be optimal to have two teachers from different disciplines (natural and cultural sciences) to facilitate communication across disciplines. Currently, such a course is in the planning stage under the roof of "heiSKILLS", the Competence and Language Centre at Heidelberg University. The course "Findings from Developmental Psychology for Application" described here can be viewed as a first step toward this enterprise.

Conclusions

Locked in the "ivory tower" or connected to our world? If we want university graduates to become science messengers in our society, we need to support them in developing skills for communicating with different groups and populations. One way to achieve this is by developing courses specifically targeted to science communication, including teacher input, reflections and practical experiences. In the two courses described here, students in this seminar have developed and documented their ability to communicate scientific findings to the broad public, which will eventually allow for making a transformative use of scientific findings. From the courses described here, the following recommendations regarding the development of broader science communication courses can be drawn:

- The number of projects needs to rather limited, to allow teachers to provide regular and individualized feedback for course projects. I would recommend limiting the number of projects to 5-7.
- One way to enable more students to participate in the course while keeping the number of projects limited would be to form small groups (2-3 people) working on one project together.
- Transfer (within the course) can be facilitated by (1) providing input, (2) having a small transfer phase within the session where students can try to employ the input they just received, and (3) enabling students to develop their own communication project over the semester.
- Students should be encouraged to provide each other (appreciative) feedback on their projects. In the current course, students provided each other with highly valuable and easy-to-accept feedback. However, in certain contexts, phrasing supportive, appreciative feedback might be an initial course goal. This might for example be necessary when working with interdisciplinary student groups. Experiences from my current Science Communication course indicate that students may sometimes fail to appreciate the value of other disciplines, which might negatively impact their feedback to students communicating science from these fields.
- The topic and medium of the science communication project should remain the student's choice. While teacher's feedback may support students' selection of appropriate content, form and style, determining the project by oneself likely exhilarates students' motivation, in accordance with self-determination theory (Ryan & Deci 2000).

The question of how to communicate with people in ways that facilitate their grasp of science and scientific findings is, in my view, central to an informed society that is capable of making important decisions. I believe it is the responsibility of scientists to foster exchange with different individuals, groups, and organizations in order to learn what moves people and

why, and what they require from science to make informed decisions. Even students who do not aspire to become scientists should be able to communicate science: While they may not be involved in creating new findings, they need to bring the knowledge they have acquired during their studies into the world.

Therefore, teaching students basics and applications of science communication is an extremely important task, which should be targeted in (all?) university curricula. The Psychological Institute has seen this necessity and incorporates science communication into their newly developed Masters' programme. Other institutions are currently drawing the same conclusions, such as the heiSKILLS Centre, which plans to develop science communication curricula for young scientists and students. The courses presented here may serve as a starting point for this venue.

At its core, teaching is communication. Therefore, it is no surprise that participating in this course has furthered my conviction to focus on science communication as a central ability for Psychology students. When I improve my communication with the students, I am leaving my ivory tower and may effectively teach them both specific content and communication skills effectively. In the long run, this is the most fulfilling way of science communication as the outcomes will multiply if students take these lessons into their worlds.

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Appendix

The Science Communication Products

Students' products, the outcomes of this course, were stored in an open science repository for reference, and were made publicly available. They can be accessed via the incorporated links:

1. Flyer for parents of babies born prematurely, https://osf.io/yz3h5/files/osfstorage/638c98061af911106dbe9ee1
2. Booklet for parents wondering about the attentiveness of their children, https://osf.io/yz3h5/files/osfstorage/638c98061af9111070bea01a
3. Podcast for childcare professionals and/or parents of children from separated families, https://osf.io/yz3h5/files/osfstorage/649433bd6513ba057e3a3471 (about: https://osf.io/yz3h5/files/osfstorage/649433ae67aff80664edf6c7)
4. Advanced training session for childcare professionals on child endangerment, https://osf.io/yz3h5/files/osfstorage/638cf8e8ce9fd112c3ea77cd

Table 1

Content of each session of the course „Findings from Developmental Psychology for Application“. All slides can be found at https://osf.io/stp8q/.

#	Content	Teaching & Learning Activities
1	General Guidelines, Introduction to Science Communication	- Input on course guidelines - Focus on practical aspect of creating an individual science communication project, discussing different options and stressing individual creative leeway - Exchange on topics of developmental psychology, experiences with science communication & questions - Input on Science Communication: who, what, to whom, why
2	Search for Science Communication Content & Written Collection of Potential Topics	Search guided by the following questions - Where do/did you get into touch with topics from Developmental Psychology? - To whom do you want to communicate/who do you want to help? - Which content could be important for your target audience? - Which challenges do you foresee? - Which format(s)/media would be suited for your purpose? → First ideas submitted in written form for feedback → Feedback from teacher in written form
3	Basics of Didactics for Adult Education	- Survey: Which courses in advanced training have I enjoyed? What was enjoyable about them? What did it trigger? What would I wish for if I participated in advanced training – what not? - Input on adult education/didactics: Steps for planning sessions Taxonomy of learning goals The sandwich principle Constructive Alignment

		- Group activity: planning an advanced training session on the topic of „Challenges in Development“ for childcare professionals - Input Devising learning material List of methods resources
4	Development of Own Science Communication Project	- Defining target audiences - Formulate learning/experience goals - Develop broad structure: Potential sub-topic Central theme - Literature search: Sufficient literature available? Otherwise, adapt audience, goals and/or structure
5	Basics of Counseling with Families	- Survey: What experiences with psychological counseling have you made? Which basic recommendations do you know? - Input on counseling with families: Basic attitude of counselor Empirical data on educational counseling Building blocks of educational & family counseling Video-based interaction counseling - Exercise on video-based interaction counseling
6	Case Studies & Supervision	- Role play of counseling cases - Feedback & supervision of case studies
7	Science Communication Research	- Input: Appropriate representation of data Considering the target audience Engaging the public Measuring the success of science communication Debunking
8-10	Counseling for Own Science Communication Project	30 minutes sessions with individual participants Participants present current status of own project Feedback by teacher Discussing further ideas
11-14	Presentation of Own Science Communication Project	Each student presents his/her own work Up to 4 contributions per session Depending on the format, presentation will be in class (e.g., session of advanced studies) or flipped classroom (texts, flyers, podcasts…)

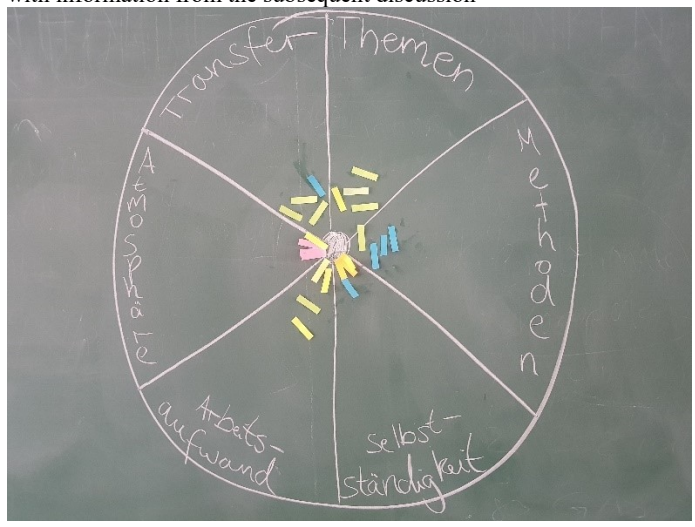
		Each project is embedded with reasons for selection of topic and development Feedback from whole class, which students should consider for their written critical reflection
15	Review & Reflection	Brief review of input sessions Overarching feedback from teacher: Classroom atmosphere Quality of students' contributions Overarching goals of the course Feedback from students (anonymous dartboard with subsequent discussion): Methods Topics Independence Work load Classroom atmosphere Transfer Further ideas

Table 2
Experiences during sessions of the course „Findings from Developmental Psychology for Application“.

#	Content	Implementation
1	General Guidelines, Introduction to Science Communication	- Input phase: Course structure - Group reflection: Students: could well identify examples of science communication had relatively little practical experience with topics from developmental psychology that might be relevant for science communication voiced some concern regarding the project character of the seminar, being unsure about what to expect and what was expected from them (while being excited by these possibilities at the same time) - Input phase: Introduction to science communication
2	Search for Science Communication Content & Written Collection of Potential Topics	- Flipped Classroom session: Students searched topics for science communication projects - Despite students' initial concern regarding little experience with developmental psychology and the courses' open project character, the collection of potential topics was very goal-oriented and fruitful - This can be verified by comparing proposals to final products all four proposed topics were implemented as products: all four proposed topics employed the science communication method proposed in the initial collection all four proposals were later refined in terms of sub-topics, central themes, and design/layout - Overview of responses to questions: Where do/did you get into touch with topics from Developmental Psychology? As intended, highly individual responses, identification of topics that were relevant for each student To whom do you want to communicate/who do you want to help? As intended, highly individual responses, identification of target groups that seemed to require science communication by each student Which content could be important for your target audience? Partly very elaborate responses, partly general collections of questions to be explored throughout the course Which challenges do you foresee? Only one student identified potential challenges regarding the aspect of science communication, and did so very precisely. She anticipated difficulties to identify and filter relevant content, and to briefly and comprehensibly communicate different

		opinions and scientific findings to laypeople, especially when addressing the highly heterogeneous public of young parents. Which format(s)/media would be suited for your purpose? As intended, highly individual responses, considerations of media channels that seemed fruitful for each content and target group Description of selected course works: flyer for parents of infants born prematurely; info booklet for parents worrying about their childrens' attention and concentration; podcast on parent separation and the effects on children, intended for childcare professionals and/or parents; an advanced training session on child endangerment for childcare professionals → Feedback from teacher: feedback was provided regarding the suitability of proposed topics and formats (all excellent), and potential challenges, further sub-topics and open questions
3	Basics of Didactics for Adult Education	- Verbal survey on students' experiences in higher education: all students had participated in courses they had enjoyed What was enjoyable about them? What did it trigger? All students reported enjoying courses where they could actively participate, the teachers seemed inspired, and individual topics could be selected. What would I wish for if I participated in advanced training – what not? In contrast to aspects the students had enjoyed in former classes, they listed purely front-of-class teaching and exclusive knowledge transmission as aspects they would not wish for. They described that exchange with the other students was very valuable, but that teachers should nonetheless add information to what is discussed among students. - Input parts: Students participated actively, asked questions and complemented the input with examples for well-conducted classes they had experienced Particular interest in video-based interaction therapy - Group activity: planning an advanced training session on the topic of „Challenges in Development" for childcare professionals Students were paired for 20 minutes to plan the training session Input provided: learning goals of the advanced training session for childcare professionals (being able to decribe developmental challenges, to sensitively accompany children in these situations, and to communicate with parents in a cooperative and solution-oriented manner) instruction to employ the sandwich-principle In principle, students were well able to plan a training day employing the sandwich principle and aligning it with learning goals

		However, planning the training day was aggravated by students' limited familiarity with early childcare professionals' level of expertise
4	Development of Own Science Communication Project	- Flipped Classroom - Intermediate results did not need to be handed in
5	Basics of Counseling with Families	- Verbal survey on experiences with family counseling: The survey indicated very little experience with family counseling (highly individual horizon of experiences, based on courses taken and internships undertaken previously) Moreover, few general guidelines for counseling could be recalled - Input on counseling with families: Building blocks of educational & family counseling were of special interest to students → focused discussion - Exercise on video-based interaction counseling: Collecting and discussing observations from a mother-infant interaction Training conversation with the client, focusing on identification of appropriate behavior examples and positive feedback Discussing why counseling (in contrast to therapy) focuses on positive situations + feedback
6	Case Studies & Supervision	- Session post-poned due to sickness of most participants
7	Science Communication Research	- Session post-poned due to sickness of most participants
8-10	Mentoring for Own Science Communication Project	- Each student presented the status quo of their course work in individualized mentoring sessions with the teacher - 30 minutes sessions were sufficient (in presence or online), plus written feedback for course works that worked with visualizations (e.g., slides or flyers) - Each course work was very well developed - For support, I provided additional references/resources, questioned the target group and main/secondary messages, and mostly gave tipps for implementation - Most tipps were directed towards scope/extent of the content, visual design and comprehensibility of content
11-14	Presentation of Own Science Communication Project	- Each week, presentation of one student - Flyer, booklet and podcast were presented in flipped classroom format, so that course sessions could focus on embedding the science communication project (why were selections made, what reasoning stood behind decisions taken) and feedback from the group

		- Feedback from the group was deemed extremely valuable, both by presenters and the teacher, and was complemented by teacher‘s feedback - What worked well: very well selected contents; very well tailored to target groups, flyer & booklet very well designed - What might be improved: partly too dense/too much information, sometimes language too demanding
15	Review & Reflection	-Due to sicknesses, the last session was expanded to include uncovered topics. In agreement with the students, the part „role play of counseling“ was omitted because no student had selected a counseling project, so this seemed less important than input on science communication research (more general implications). - Brief review of input sessions provided by the teacher: main messages from each session - Overarching feedback from teacher: Excellent, dedicated and warm classroom atmosphere Excellent quality of students’ contributions, potential for real-life applications of several course works Reminder to incorporate feedback from the teacher and the group into the reflexion classwork - Feedback from students: Figure of anonymous dartboard, supplanted with information from the subsequent discussion  - Methods (Methoden): considered appropriate - Topics (Themen): considered highly interesting - Independence: valued greatly

		- Work load: considered appropriate to a little high; students estimated their net-working time towards their own course work between 2-5 full days (~ 16-40 hrs) - Classroom atmosphere: excellent - Transfer: student rated their ability to transfer knowledge from this course to their work as a psychologist as excellent - Further ideas: More input from teacher desired; when teaching this course with a larger group, working together on group projects would balance the workload for both students and teacher

Table 3
Content of each session of the course „Science Communication“.

#	Content	Teaching & Learning Activities
1	General Guidelines	- Input on course guidelines - Introduction of teacher: why am I teaching this course and what is my qualification (disclaimer: developmental psychologist in the first place, not a researcher on science communication!) - Definition of science communication - Homework: Contemplate: Where are you in contact with science communication, when would you wish for science communication? Ask friends & acquaintances: Where are they in contact with science communication? Which input from Psychology would be of interest for them?
2	Introducation to Science Communication	- Differentiation science communication & science journalism - Input Science Communication: Who? What? To whom? - Homework: collecting science communication examples: good/bad ones from all kinds of media
3	Science Communication Examples – Deriving a Practical Guide	- Group exercise: Read/watch/listen to different examples of science communication Collect recommendations for best practices - Discussion about outcomes of group exercise - Homework: hand in recommendations → teacher develops a comprehensive practical guide
4	Communication Goals & Strategies	- Defining target audiences - Formulate learning/experience goals - Develop broad structure: Potential sub-topic Central theme - Literature search: Sufficient literature available?

		Otherwise, adapt audience, goals and/or structure - Practical exercise: apply practical guide to a science communication example
5	Psychological Principles of Science Communication	- Communicator's attitude & demeanor - Earning the audience's trust - Elaboration Likelihood Model - Preventing reactance - Biases & heuristics - Cognition & emotion - Homework: thinking about topic for practicing science communication
6	Developing an „Elevator Pitch"	- Input on elevator pitch: What Why How - Practical exercise: each student selects a topic they develop an elevator pitch successively through feedback from different partners
7	Visualizations & Statistics	- Input: Appropriate representation of data Psychological research on visualization/statistical understanding - Group exercise: Developing ideas how to improve (statistical) visualization in science communication examples
8	Developing my Own Topic	- Individual exercise: Which content from Psychology would you like to communicate? To whom do you want to communicate? Which content could be important for your target audience? What goal(s) do you address during communication? Which challenges do you foresee? - Presentation & feedback in small groups
9	Coherent Writing	- Online session - Input on principles of coherent writing: Formulating short main sentences Reducing nominalizations Employing active and positive sentences

		Reducing expletives - Individual, anonymous exercises with discussion (what is the most coherent way to write the sentence?)
10	Blogposts & Full Articles	- Input: guidelines for In-Mind (de.in-mind.org) blog posts and articles - Individual exercise: writing first draft of blog post employing the method of 5-paragraphs - Homework: hand in first draft → individual feedback for each student
11	Science Communication in Dialogue Format	- Survey: (Why) Is a dialogue form desirable? Are there cases in which instructive communication is preferable? (which?) What could be obstacles for a dialogue form? Which formats would facilitate a dialogue between scientists and laypeople? - Input on status quo of dialogue format: Social media Citizen science Surveys - Group discussion: developing creative ideas to enhance participation in dialogue communication - Homework: hand in revised version of blogpost
12	Anchoring Science Communication in the Scientific System	- Group exercise: Each group reads a short article on science communication in different societies/scientific systems Participants switch teams to inform each other - Discussion: Collecting best practices for anchoring (supporting) science communication Developing creative ideas how to support science communication
13	Review & Reflection	- Brief review of each week's main content: powerpoint karaoke - Clarifying potential questions regarding the In-Mind science communication article (to be written during the semester break) - Discussing the anonymous course evaluation - Group discussion:

		Which main messages do I take from this course? What would be desirable if this course is taught again?