bioCEED – Centre for Excellence in Biology Education 2014-2023

Ten years in pursuit of excellent biology education

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Preface

The Centre for Excellence in Biology Education – bioCEED, has from 2014-2023 been a centre under the scheme of Centres for Excellence in Education (SFU), and is a consortium consisting of the Department of Biological Sciences (BIO) - University of Bergen (UiB), Department of Arctic Biology (AB) - University Centre in Svalbard (UNIS), Department of Education (UiB) and the Institute of Marine Research (IMR).

This report is based on our end-reporting to the Norwegian Directorate for Higher Education and Skills (HKdir). Specifically, we provide an overview of bioCEED activities and impacts since 2014. Our approach is a series of reflective essays, preceded by an introduction and including separate chapters focusing on the bioCEED focus areas: Learning Culture, Innovative Teaching and Practical Training. In addition, there is a dedicated chapter on Students as Partners, which has emerged as an additional, albeit important, strategy across the original focus areas. Additional information, including (more) numbers and impact reports, can be found on bioCEED.no.

You will notice a varied writing style and diverse scholarly perspectives in the different chapters of this report, which reflects the diverse and interdisciplinary composition of the bioCEED team and our approaches. The Learning Culture and Students as Partners chapters focus on approaches for engaging students and educators, aiming to support cultural change. The Innovative Teaching chapter is grounded in the principles of scientific teaching and research-based education. The chapter on Practical Training uses the personal and professional experience of those teachers and hosts that developed a novel approach to practical training in disciplinary biology education.

The main body of text in the report is written by Sehoya Cotner, Tina Dahl, Kristin Holtermann, Jonathan Soulé and Oddfrid Førland, citing several bioCEED texts and reports including the application text, annual reports and toolkits developed by the extended bioCEED team. In addition, we have included texts written by Yael Harlap, Vigdis Vandvik, Lucas Jeno, Pernille Bronken Eidesen, Gro van der Meeren and Gaute Velle. Testimonials given by different stakeholders in bioCEED are built in throughout the report. During the writing of this report, we have had valuable comments from Steve Coulson, Pernille Eyde Nerlie and Ruben Thormodsæter.

We would like to extend a sincere thanks to the partner institutions UIB, UNIS and IMR, for their support and investment in bioCEED. Likewise, we are profoundly grateful to the funding institutions that supported us: the Norwegian Agency for Quality Assurance in Education (NOKUT) and the Norwegian Directorate for Higher Education and Skills (HKdir). We thank our fellow SFUs for the community and collaboration over these ten years, with a special thanks to the Centre for Research Innovation and Coordination of Mathematics Teaching (MatRiC) and the Centre for Integrated Earth System Education (iEarth). We appreciate all our project and collaboration partners involved in our different activities, especially the Center for Engineering Education (CEE), LTH (Lund University), and the Norwegian Research Centre AS (NORCE).

None of these pages would exist (that is, there would be nothing to report on) without the efforts and inspiration of Vigdis Vandvik, the lead author of the SFU proposal and the primary leader of bioCEED (through 2021). Her impact is distributed throughout every chapter, even in places where she is not mentioned. We are immensely grateful to Vigdis for being a pioneer of bioCEED, and, in so doing, changing the culture of (biology) education in Norwegian higher education.

Most of all we thank all the students, teachers and educators at BIO and AB that have engaged, developed, challenged, innovated and supported bioCEED. The true excellence in education is you.

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List of Abbreviations

Abbreviations	Definition
AB	Department of Arctic Biology, University Centre in Svalbard
BIO	Department of Biological Sciences, University of Bergen
bioCEED	Centre for Excellence in Biology Education (2014-2023)
BSc	Bachelor of Science
CALEQ	Constructive Alignment Learning Experience Questionnaire
CEE	Center for Engineering Education, LTH, Lund University
CEQ	Course Experience Questionnaire
CL	Cooperative Learning
CoP	Community of Practice
DEVELOP	Developing evidence-based mentoring for better STEM work placements (project)
ECom	Educational Committee at UNIS
ECTS	European Credit Transfer and Accumulation System
ETP	Excellent Teaching Practitioner
FieldPass	Development, testing and evaluation of tools and assessment forms that promote course alignment in field and lab teaching (project)
HKdir	Norwegian Directorate for Higher Education and Skills / Direktoratet for høyere utdanning og kompetanse
iEarth	Centre for Integrated Earth System Education
ILO	Intended Learning Outcomes
IMR	Institute of Marine Research (in Norwegian, HI - Havforskningsinstituttet)
IMRaD	Introduction, Methods, Results, and Discussion
LF	Learning Forum at UNIS
LLM	Large Language Models
LTH	Lunds Tekniska Högskola, The Faculty of Engineering at Lund University
MatRIC	Centre for Research Innovation and Coordination of Mathematics Teaching
MN Faculty	The Faculty of Mathematics and Natural Sciences at UiB
MNPED660	Collegial Teaching and Learning Course in Biology/STEM
MNT	Mathematics, Natural Sciences and Technology
MSc	Master of Science
NGO	Non-Governmental Organisation
NOKUT	Norwegian Agency for Quality Assurance in Education / Nasjonalt organ for kvalitet i utdanninga
NORCE	Norwegian Research Centre AS
PFTC	Plant Functional Traits Course
PhD	Doctor of Philosophy
PLO	Program Learning Outcomes
PRIME	How implementation of Practice can Improve relevance and quality in discipline and professional Educations (project)
ReDesign	Student-active research and transferable skills in redesign of the biology education (project)
SCOPE	Student-led Conference on Polar Environment

Abbreviations	Definition
SFU	Centre for Excellence in Education / Senter for fremragende utdanning
SOLO	Structure of Observed Learning Outcomes
SoTL	Scholarship of Teaching and Learning
STEM	Science, Technology, Engineering and Mathematics
TA	Teaching Assistant
TBL	Team-Based Learning
UiA	University of Agder
UiB	University of Bergen
UiO	University of Oslo
UiT	The Arctic University of Norway
UNIS	The University Centre in Svalbard
UPED	Program for University Pedagogy, University of Bergen
VFG	Virtual Field Guide
WP	Work Package

Summary

bioCEED was built on the vision that biology, and biologists, emerge in the interplay between biological theory, the practical applications of biological knowledge, and the relevance of biological theory and practical knowledge for society. The 'domain of biology' is defined by the interactions between the development of scientific content knowledge and practices within biology itself, and society's applications of this knowledge and these skills. Biology education must therefore prepare our students for demanding roles in science and society, and for complex challenges in their future careers.

Our overarching approach to develop biology education can be summarized in three points:

1. Make use of the whole biological triangle in biology education (research-based education, skills training, work and societal relevance)
2. Focus on the students, and what benefits their learning (evidence-based teaching)
3. Exploit the research culture to grow a collegial and scholarly culture of teaching and learning (Scholarship of Teaching and Learning (SoTL))

The introductory chapter describes our development as a centre and summarizes the underlying principles for all our activities, namely: (i) education and educational development should be *research based*, (ii) our initiatives and innovations should be based on a *collegial and scholarly approach*, and (iii) *students should be partners* in education, educational development, and research. Further, we reflect on the reach and impact of bioCEED.

In the chapter Learning Culture, we direct the reader to our emphasis on the multiple ways in which people could engage with bioCEED — from low- to high-effort, and from short-term participation to more sustained collaborations. We use our outreach activity over ten years to show how we have engaged educators in conversations about teaching and learning. We conclude the chapter with our ten recommendations for supporting a cultural shift towards a collegial culture that emphasizes SoTL.

The Students as Partners chapter tells the story of our evolution from a Centre in which students were initially involved as representatives and informants to one in which they became partners, contributing in various ways to development, implementation, analysis, and decision-making within teaching and learning. We provide examples of activities, student projects and co-creation to illustrate this point.

In the chapter Innovative Teaching, we give examples of bioCEED facilitating our colleagues' implementation of novel and evidence-based teaching. A consistent theme throughout is the use of SoTL in the service of better education and creating a knowledge base for further development. In this chapter, we also describe the tools and resources that have been created, assessed, shared, and maintained by bioCEED.

The Practical Training chapter describes our accomplishments with embedding authentic

learning experiences into the curricula. We include examples of courses and networks that support students engaged in work practice, as well as examples of course-based research experiences. Four key bioCEED people contributed individual reflections to this chapter.

Samandrag

bioCEED sin visjon er at biologi, og biologane, oppstår i samspelet mellom biologisk teori, den praktiske bruken av biologisk kunnskap og biologien sin relevans for samfunnet. Det biologiske domenet er definert av samspelet mellom utvikling av kunnskap, praktiske ferdigheiter og bruk av kunnskapen og ferdigheitene i samfunnet. Biologiutdanning må derfor førebu studentane på krevjande roller i vitskap og samfunn, og for komplekse utfordringar i deira framtidige karrierar.

Vår overordna tilnærming til biologiutdanninga kan samanfattast i tre punkt:

1. Ta i bruk heile biologi-triangelet i biologiutdanninga (forskingsbasert utdanning, ferdigheitstrening og samfunnsrelevans)
2. Fokus på studentane og det som fremjer deira læring (evidensbasert undervising)
3. Utnytte forskarkulturen for å byggje ein kollegial og forskande kultur for undervising og læring (Scholarship of Teaching and Learning, SoTL)

Innleiinga skildrar vår utvikling som senter og oppsummerer dei underliggjande prinsippa for våre aktivitetar: (i) utdanning og utdanningsutvikling skal vere *forskingsbasert*, (ii) våre initiativ og innovasjonar skal vere basert på ei *kollegial og vitskapleg tilnærming*, og (iii) *studentar skal vere partnarar* i utdanning, utdanningsutvikling og forsking. Vidare reflekterer vi over rekkevidda og påverknaden til bioCEED.

Kapitelet Learning Culture fortel om vårt arbeid med å skape vegar til å engasjere seg i bioCEED på – frå låg til høg innsats, frå kort- til langvarig engasjement. Med spreiingsaktiviteten vår som grunnlag, viser vi korleis vi har engasjert undervisarar, studentar, og andre utdannarar i samtalar om undervising og læring. Vi avsluttar kapittelet med våre ti råd for å støtte ei kulturendring mot ein kollegial og kunnskapsbasert læringskultur (SoTL).

Kapitelet Students as partners fortel historia om vår utvikling frå eit senter som involverte studentar som representantar og informantar, til eit senter der studentane er partnarar som bidrar på ulike måtar til utvikling, implementering, analyse og avgjerder i undervisingsutvikling. Vi viser til konkrete døme på partnarskap og samskaping.

I kapittelet om innovativ undervising viser vi ei rekkje døme på korleis bioCEED har jobba for å utvikle og implementere måtar å drive nyskapande og evidensbasert undervising i biologi. Eit gjennomgåande tema er bruken av SoTL for å styrke utdanningskvaliteten og sikre ei kunnskapsbasert utvikling. Kapitelet skildrar også læringsverktøy og læringsressursar vi har utvikla, evaluert og delt.

Arbeidet med praksis og arbeidslivsrelevans er samanfatta i kapittelet Practical Training. Her deler vi våre erfaringar med å implementere autentiske læringsopplevingar i utdanninga. Vi skildrar emne og samarbeid som gjer studentar arbeids- og forskingspraksis. Fire nøkkelpersonar i bioCEED deler sine refleksjonar og erfaringar.

1. Introduction

The domain of biology in society is expanding, and this expansion is driven by the interplay between biological content knowledge, a rapidly increasing skills 'toolbox', and the increasing demands of society for individuals with these insights and skills (UiB, 2013).

The bioCEED consortium merged the strengths of BIO at UiB—a large department in a large university, with a broad range of teaching and research offerings and many societal links—with AB at UNIS—a smaller, more specialized department in a close-knit academic environment. These two departments are joined by the Program for University Pedagogy at UiB (UPED) and Norway's largest centre of marine science (IMR), with close links to industry and government (UiB, 2013). Together, these four units have been the core of bioCEED.

The consortium applied to become a SFU in 2014. The vision of the Centre can be summed up with the statement in the application (UiB, 2013, p.1):

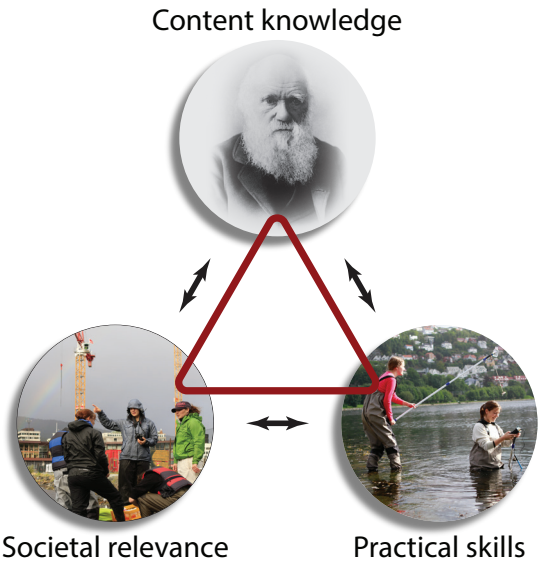


Figure 1.1. *The domain of biology - the bioCEED triangle. (Photos bottom corners by C. Irgens).*

"Current developments within the biological sciences are profoundly impacting society, and our vision is that this 'biological revolution' should shape not only the content of biology programmes and courses, but also how biology is taught. bioCEED therefore expands on our existing collaboration to reshape biology education in response to changes in the biological sciences, in higher education, and in society's needs. The new centre will enable development and research-based assessment of learning practices that strengthen the knowledge base, skills sets, and vocational integrity of tomorrow's biologists. The centre will significantly promote sharing of 'best practice' within bioCEED, across the educational sector, and with society".

bioCEED argued that the 'biological triangle' (Fig. 1.1) should have implications, not only for *what* we teach, but also for *how our students are trained*. Our overarching approach to developing biology education can be summarized in three points:

1. Make use of the whole biological triangle in biology education (research-based education, skills training, work, and societal relevance)
2. Focus on the students, and what benefits their learning (evidence-based teaching)
3. Exploit the research culture to grow a collegial and scholarly culture of teaching and learning (SoTL)

bioCEED aimed to offer students, from day one of their education, learning experiences that span the entire domain of biology (Fig. 1.1). This included developing and testing new learning practices targeted specifically at promoting the knowledge base, skills, and integrity required by the different roles biologists occupy in society. We promoted sharing of 'best practice' within the centre partners, at our institutions, across the educational sector, and within society (UiB, 2013).

When designing a comprehensive plan for the Centre's strategies and actions, the framework of Gibbs (2009) provided a guide to ensure that important aspects were included (the "Gibbs list"). The "Gibbs list" describes actions on different levels of teaching and learning, including individual, collegial, and institutional levels, addressing obstacles and highlighting effective strategies to change higher education.

bioCEED was initially organized in eight Work Packages (WPs, Fig. 1.2, left). These are linked to the centre's core strategies and represent multiple perspectives on educational quality and development (UiB, 2013). WP 1-4 represented key determinants of quality within education per se, whereas the WP 5-7 represent surrounding fields and processes that affect educational quality (Fig 1.2, left). From 2016, we re-organized and communicated bioCEED activities and outcomes under the four focus areas of *Teacher Culture*, *Innovative Teaching*, *Practical Training*, and *Outreach* (Fig. 1.2, right), and the initial WPs became an underlying structure. The focus area Teacher Culture was later re-named Learning Culture: "*This broad involvement in general, and the student initiatives in particular, have led us to question the very name of Focus Area 1, Teacher culture, which seemed so appropriate only a couple of years back. Now it feels oddly outdated and narrow, and we ask: Is 2019 the year when bioCEED renames this focus area A Learning Culture, to reflect that the learning partnership involves the full breadth of students and educational staff within and beyond higher education programmes and institutions?*" (bioCEED, 2018).

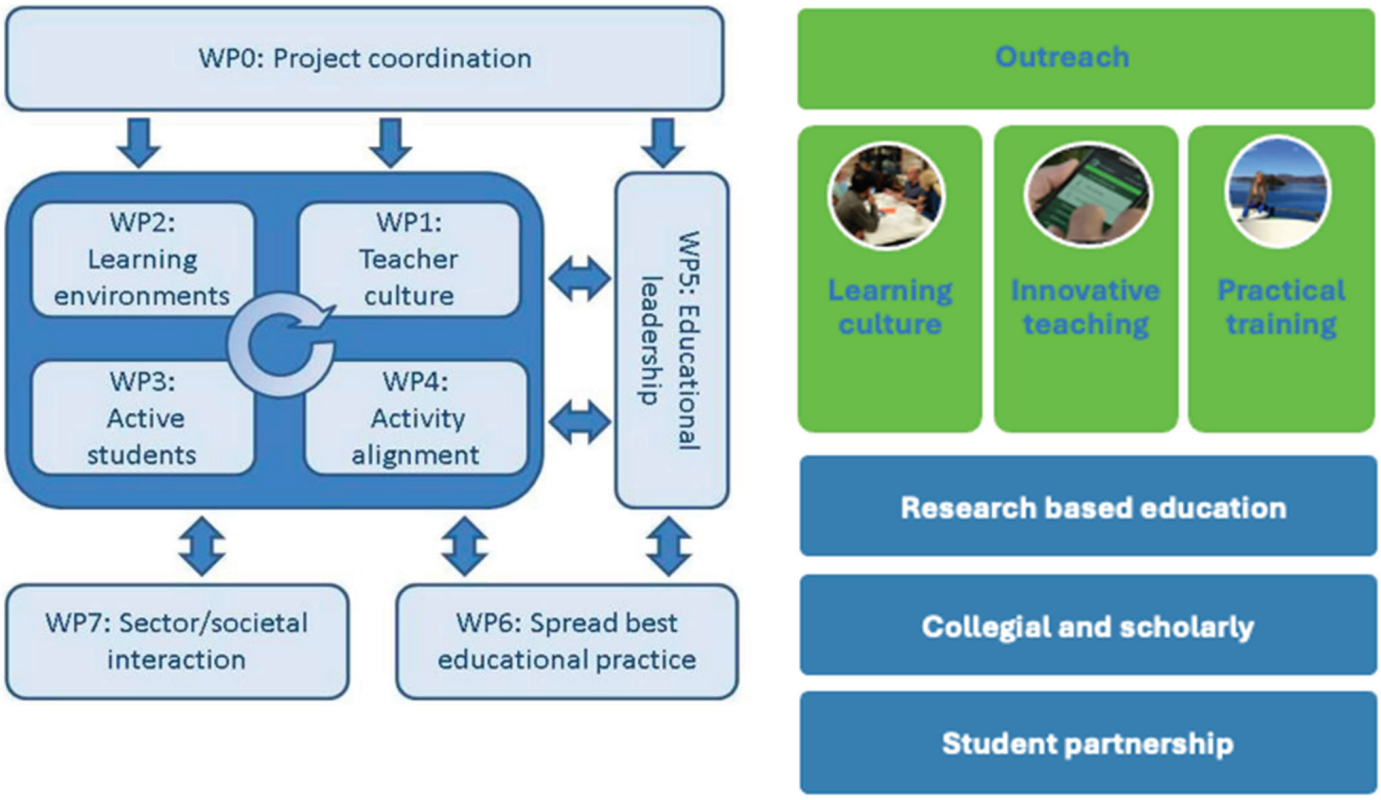


Figure 1.2. *Organizations of bioCEED's WPs during phase one (2014-2018, left) and focus areas during phase two (2019-2023, right).*

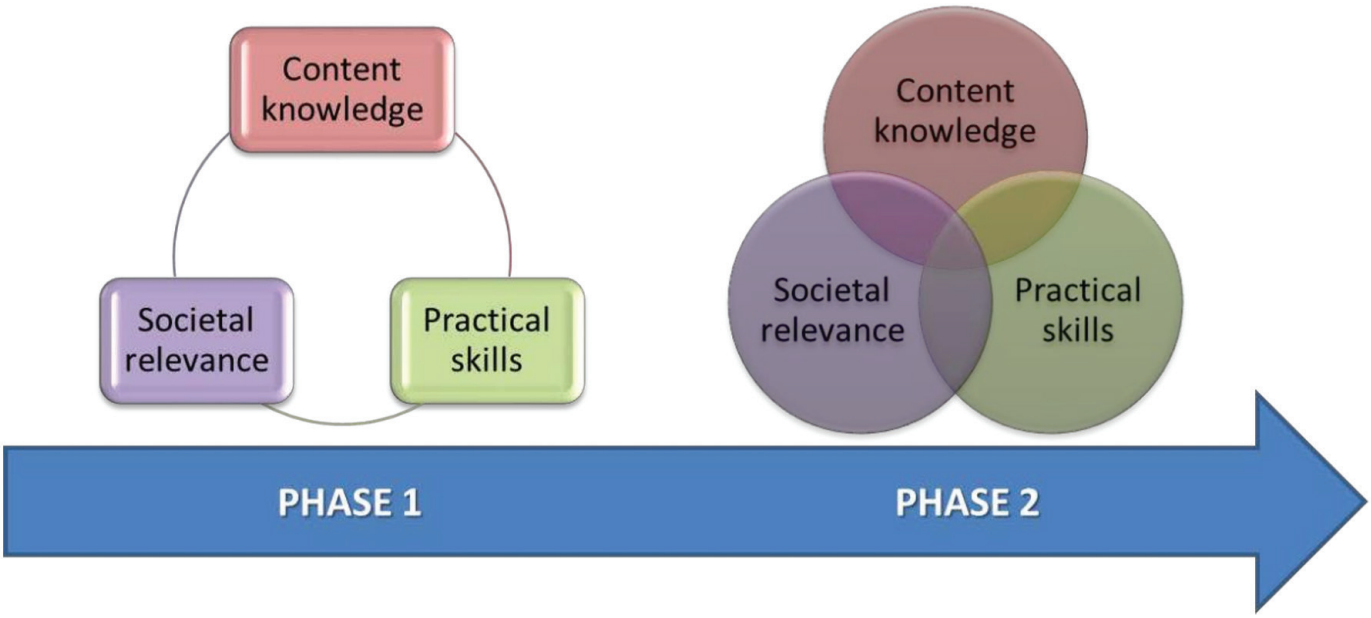


Figure 1.3. *The evolution in the use and understanding of the bioCEED triangle over time from phase one (2014-2018) (right) to phase two (2019-2023 (left). Initially (left), the focus was on linking three separate areas in biology. Later (right), the approach became more holistic, expanding and connecting these areas more closely with each other.*

The underlying principles for all our activities are that (i) education and educational development should be *research based*, (ii) our initiatives and innovations should be based on a *collegial and scholarly approach*, and (iii) *students should be partners* in education, educational development, and research (Fig. 1.2, left).

Following the advice and input from the evaluation committee during the mid-term evaluation in 2017 (NOKUT, 2017), bioCEED developed a *vision statement* (Fig. 1.3), to show the evolution in how the bioCEED triangle has been understood and used – from the early-stage focus on interlinking three different and distinct aspects within the domain of biology (Fig. 1.3, left), to the later-stage more holistic approach that expanded the scope of each of the three aspects, while also integrating and linking them more closely with each other (Fig. 1.3, right) (bioCEED, 2017b).

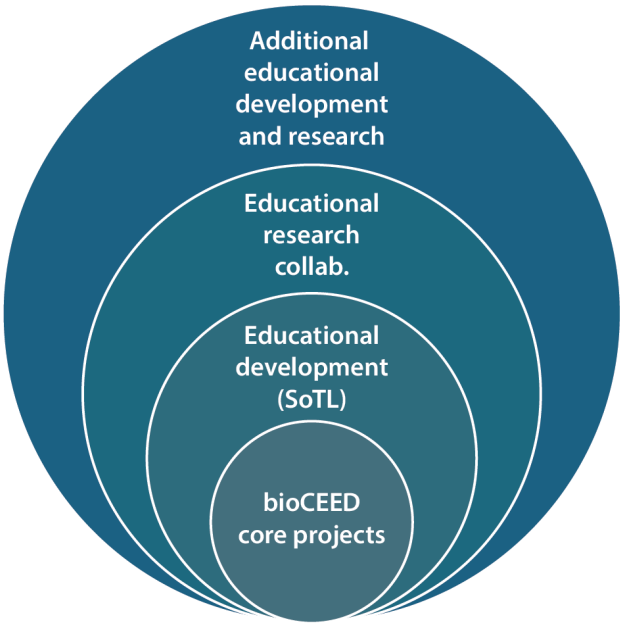


Figure 1.4. *Building on core bioCEED activities to increase activity and reach.*

Expanding reach and activity

We have expanded our reach through collaboration, project development and funding – from the core bioCEED project plan, to collaborations and additional externally funded projects. These initiatives have allowed bioCEED to deliver development and research outcomes far beyond what would have been possible with the SFU funds and resources alone (Fig. 1.4). bioCEED core projects have led to extensive educational development at our institutions, where leaders and educators have built on bioCEED experience and resources to impact teaching and learning beyond the departments within bioCEED. Further, in collaboration with institutional, national and international partners, we have been able to secure extensive additional funding through different initiatives that have

led to greater impact in our prioritized areas – beyond what we could have achieved without these collaborations and funding opportunities. For example, the project Developing evidence-based mentoring for better STEM (Science, Technology, Engineering and Mathematics) work placements (DEVELOP[1]), funded by the Program for økt arbeidsrelevans (HKdir), is a collaboration between the two SFUs iEarth and bioCEED, within the two disciplines geosciences and biology, and including three Norwegian universities (UiB, University of Oslo (UiO), and The Arctic University of Norway (UiT)), University of Minnesota (USA), and the research institutes IMR and NORCE. Finally, we have built national and international networks that enable further expansion.

Reflecting on bioCEED's impact

As we look back on ten years as bioCEED, we are proud of our achievements. The Centre has positively changed the culture of teaching and learning at UNIS and UiB (described in Chapter 2 Learning Culture and Chapter 3 Students as Partners). We are also encouraged by the examples in which bioCEED activities and approaches have been adopted for use in our departments, our institutions, as well as at other institutions across Norway (examples found in Chapter 4 Innovative Teaching and Chapter 5 Practical Training). We are confident that bioCEED initiatives will continue to spread and influence higher education, and bioCEED efforts will be felt beyond our SFU period.

While we are convinced that we have accomplished far more than we set out to do, we also acknowledge that there have been shortcomings. A key challenge that was mentioned in earlier evaluations involves the reach of bioCEED (NOKUT, 2017). We have done excellent work with the "coalition of the willing" in our own departments, and we have responded positively to invitations to engage beyond AB at UNIS and BIO at UiB. We have been less involved with educators and entities that are less receptive to change, and we have not always initiated contact where it might have been welcome. Rather than engaging with more biology departments across the country, we have chosen to support successful relationships across STEM departments, and across the SFU network. This choice to be interdisciplinary can be seen as either a strength or a weakness, and that perspective will likely depend on who is evaluating these impacts.

The SFU status and funding enabled us to think big and support many meaningful endeavours over time, and we have successfully leveraged this initial investment into successful funding applications to magnify our impact. As the funding period ends, there is considerable uncertainty for the continuation of several bioCEED initiatives. Although many initiatives are now implemented in our institutions' educational activities, others are not. With increasing financial pressure and changing political priorities in the higher education section, we fear that educational development and innovation will not receive the attention it deserves to ensure that our students get the high-quality research-based, active, inclusive, innovative, and practical education they deserve. Likewise, we fear that educators will not have the support they need to develop excellent education.

In conclusion, the legacy of bioCEED will likely be less about single initiatives or individuals, but more about what can happen when motivated, complementary teams of people have the time, resources, and leadership support to think big, take risks, and think inclusively with respect to who should have a voice in the discussion.

The bioCEED Focus Areas

The broader outcomes and results are discussed in the following reflective essays: *Learning Culture, Students as Partners*, *Innovative Teaching*, and *Practical Training*. Throughout we cite comments from our colleagues, which are drawn from testimonials collected during the end reporting in early 2024.

List of hyperlinks used in this chapter

1. DEVELOP: https://dvlp.w.uib.no/

2. Learning Culture

Oddfrid Førland, Kristin Holtermann, Tina Dahl & Sehoya Cotner
with valuable contributions from the core team

Introduction and background

The vision of bioCEED can be summed up with the statement in the application (UiB, 2013, p.1):

> *Current developments within the biological sciences are profoundly impacting society, and our vision is that this 'biological revolution' should shape not only the content of biology programmes and courses, but also how biology is taught. (...) The centre will significantly promote sharing of 'best practice' within bioCEED, across the educational sector, and with society.*

To achieve this shift, bioCEED aimed to combine its vision with two strong trends in higher education:

1. Shifting from teacher-centred to learner-centred education.
2. A cultural shift towards a scholarly and professionalized approach to teaching.

This reflective essay will focus on the cultural shift. The application text outlines the main strategies bioCEED aimed to employ to achieve this, through dedicated strategies and associated work packages (WPs) (UiB 2013):

- *A collegial learning culture among teachers (WP 1: A collegial learning culture among teachers, leader: BIO)*
    - o *Shift from 'teaching' to 'learning' perspective in teacher thinking and practice.*
    - o *Develop a culture of shared responsibility for students, courses, and programmes.*
    - o *Create physical, social, and virtual 'spaces' for sharing experience and ideas.*

WP actions include establishing annual Teachers' Retreats, pedagogical courses and sabbaticals, collegial teacher groups, and a web forum. In addition, appoint two adjunct professors (education experts):

- *Efficient leadership of education (WP 5: Strengthen and empower educational leadership, leader: AB)*
    - o *Appoint and empower 'leaders of education' as part of institutional leadership.*
    - o *Integrate education and research in institutional strategies and goals.*
    - o *Identify and remove (infrastructure) obstacles to development and change.*
    - o *Develop links to the higher education sector (within our institutions, in Norway, abroad).*

Additional WP actions include recognition and reward for teaching efforts, and explicitly promote education, teaching and learning in all communication.

Learning culture strategies are also integrated in other WPs: e.g. *Engage staff and students in*

renewal of the broader learning environment (WP2: Learning environments); and *Enable learning and sharing of experience within bioCEED and beyond* (WP6: Spread of "best practice").

During the mid-term evaluation process bioCEED restructured its activities within three focus areas, where the above strategies and actions were continued under the focus area Teacher Culture (bioCEED 2017b), later renamed Learning Culture to better reflect the contribution of all groups involved in education (bioCEED, 2018, Fig. 1.2).

Theoretical framework and theory of change

The theoretical framework and approach adopted by bioCEED to promote a cultural shift was summarized by Førland et al. (2016):

> *The bioCEED approach was to start with the cultural development, based on the conviction that lasting and programme-wide educational development can only be achieved through growing a knowledge-based institutional teaching and learning culture, and that the only credible way of doing this is by adapting a scholarly development approach (Boyer, 1990).*

SoTL (Boyer, 1990; Mårtensson et al., 2011) is an approach where the goal of development and change is enhanced student learning. Educational development within SoTL is knowledge-based and include systematic observations and investigations. Equally important, teachers and students should have ownership of the change efforts, and SoTL include informed discussions and documentation that enable sharing, institutional learning, and cultural development (Mårtensson et al., 2011).

The approach to build this scholarly and collegial culture for teaching was communicated to our colleagues in a straight-forward manner: Bring your researcher head into the classroom! Our main message was to bring the best aspects of the researcher culture (e.g. working in groups, continuous

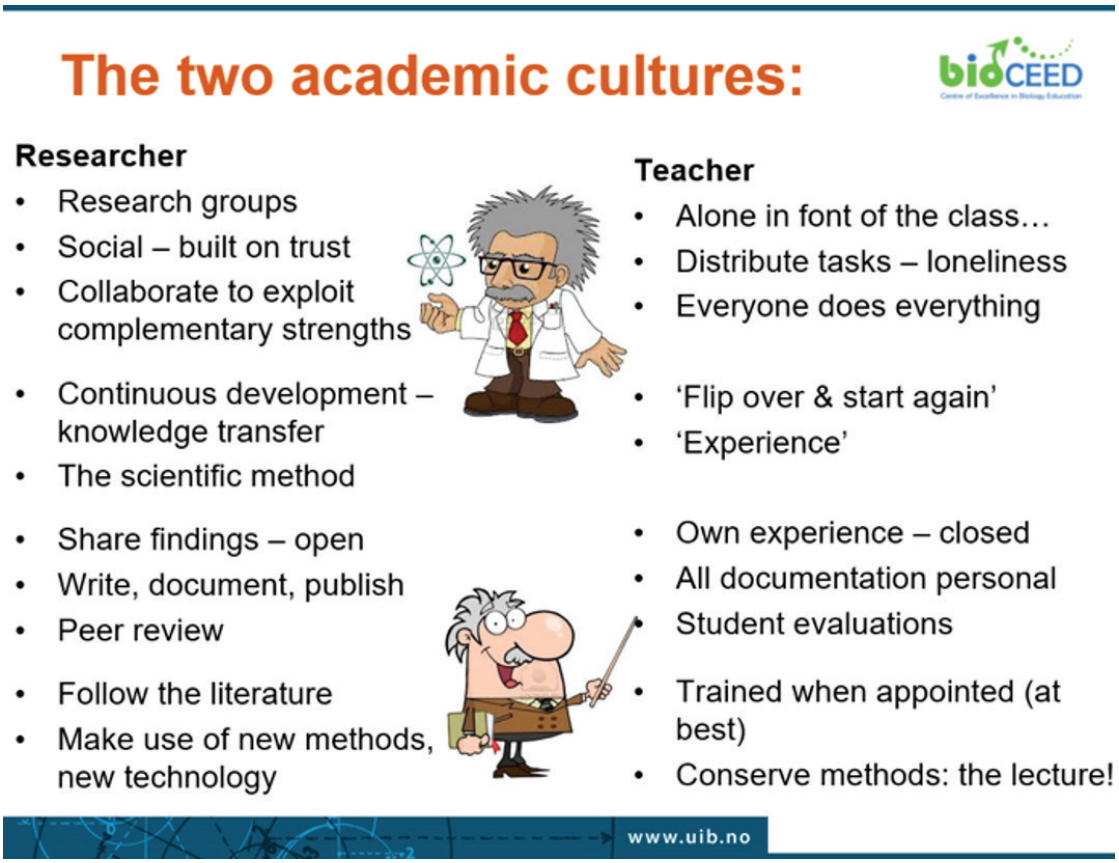


Figure 2.1. *The two academic cultures - research and teaching. Slide by Vigdis Vandvik.*

development, peer review and updated knowledge) into teaching; we have the tools we need to also have a scholarly approach to teaching and educational development (Fig. 2.1).

bioCEED profited from a close collaboration with CEE at LTH, Lund University, Sweden. LTH has a successful institutional strategy for educational quality development, including SoTL as a way of developing a quality culture (Mårtensson et al., 2011), recognition and reward for teachers that develop teaching in a systematic and scholarly way (Olsson & Roxå, 2013), and systematic student evaluation of teaching (Roxå et al., 2022). CEE's involvement with bioCEED has included filling advisory roles, participation in professional and educational development, and an adjunct associate professor - allowing bioCEED to benefit from LTH's twenty-year long experience and expertise. An important LTH strategy adopted by bioCEED was supporting more, and more *informed, conversations about teaching and learning*. This includes facilitating conversations and sharing through collegial arenas and professional development opportunities.

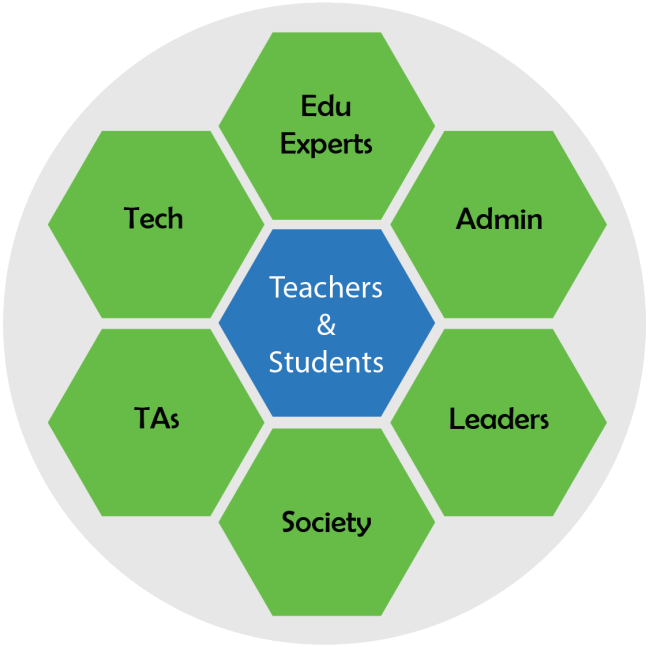


Figure 2.2. *Active involvement of all relevant groups that contribute to excellence in education.*

The bioCEED core team was from the beginning a diverse group of people, representing different positions and areas of competence (bioCEED 2014-2022[2]). The active involvement of all groups that contribute to quality in education was an important principle in all bioCEED plans and activities (Fig. 2.2). This rests on the realization that excellence in education can only be achieved if all relevant actors are *involved*, *included*, and *informed*. By that we mean expanding the collegium and involving relevant actors in all educational development projects (inform and include).

> *"... students and teachers are not the only 'players' in the educational 'game', technical and administrative staff, course assistants, educational developers, and the departmental and institutional leadership are all part of the partnership that together shape the content and quality, both in terms of the subject matter and pedagogy, of our courses and programs."*
>
> (bioCEED, 2018)

From 2019 this philosophy was made more explicit by changing the name of the focus area *Teacher Culture* to *Learning Culture* (bioCEED, 2018) to reflect that the learning partnership involves the full breadth of students and educational staff within and beyond higher education programmes and institutions. For the remainder of this text, we will mainly use the term educators to describe people (staff or collaborators, not students) involved in our projects and activities unless other specification is given.

Multiple pathways to engagement

The national survey of biology education, conducted by bioCEED in 2014-15, showed that biology teaching staff rarely discuss their role as teachers with their colleagues (Hole et al., 2016; Førland et

al., 2016), and felt that there was little appreciation and support from the institutions for educational development:

> *«I miss a forum of peers where we can exchange experiences and discuss about teaching and supervision. I think we have a lot to learn from each other. I have suggested this many times locally, but there is little interest from colleagues and leaders».*
>
> *«My experience with colleagues and leaders on sharing/giving feedback: no one can be bothered. We leave everything to individuals – and they either give up or try to make the best of things, but this comes at the expense of time for research (which is all that counts)»*
>
> *«New teaching methods would be interesting to learn, but there is rarely time for this. So I try to learn from my own experience»*
>
> Quotes from teachers in the bioCEED Survey (Hole et al., 2016)

The results from the survey (Hole et al., 2016) showed the need to strengthen support for educators in educational development. bioCEED's strategy to engage educators in educational development and support a collegial and scholarly culture for teaching and learning, was to create multiple pathways to engage and participate in the broader conversation around teaching.

The large annual events UNIS Learning Forum (LF) and BIO Teachers' Retreat, that involve the full collegium of educators, function as a backbone for the collegial activities of BIO and AB (see Boxes 2.1 and 2.2). In addition, we offer a range of opportunities (Fig. 2.3) for low-commitment participation (e.g. bioCEED seminars) and high-commitment activities like the Collegial Teaching and Learning Course in Biology/STEM (MNPED660) (Førland & Andersson, 2021; toolkit[3]).

Educators are invited to participate in activities with different levels of commitment, based on their interests, needs, experience and engagement. For example, a low-commitment activity is the Digital Teachers' Meetings that were started during the pandemic. These were at first a collegial arena for sharing and support during the rapid change to remote teaching, and later developed into a seminar

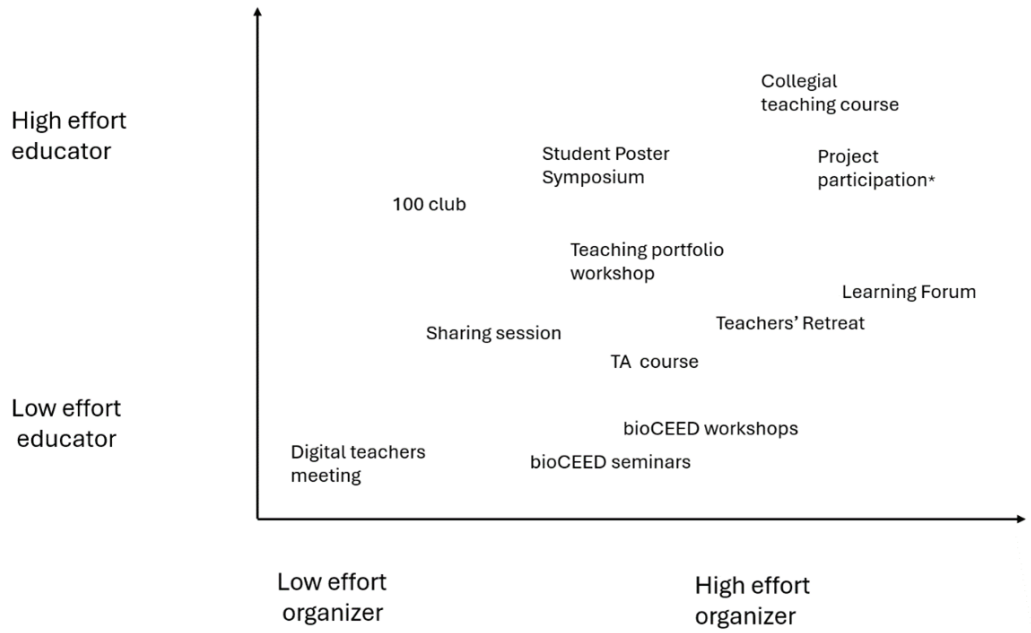


Figure 2.3. *Visualization of different collegial activities with different degrees of effort and commitment needed on the side of the organizer (bioCEED), and the participant (educators). *Project participation could involve high/low effort depending on the project and level of engagement.*

Established in 2014, the annual two-day **BIO Teachers' Retreat** invites all teachers/educators at BIO to engage in discussions and workshops about teaching and learning – with a focus on **development**. Throughout the years invited researchers, workshop facilitators, and project members have contributed with different topics such as research-based education, assessment, student active research, and curriculum development for student learning. bioCEED organized these events and provided funding, and the topics were tailored to fit current needs and interest of the teacher collegium.

At each event, teachers shared experiences, gained new knowledge, and discussed curriculum and educational development. The Teachers' Retreat has been essential in creating a common understanding, a common language, and a shared culture for learning and educational development. It provides a space for teachers to discuss teaching and learning openly. The first retreats were restricted to academic teachers, recognizing that sharing can be a new experience and difficult for teachers. Later retreats have included other staff involved in education.

Initially, it was essential, with leadership support, to signal the importance of the Teachers' Retreat, and the Head of Department sent the first invitation requiring participation from teachers. Later, as the Teachers' Retreat became a valued event that teachers looked forward to, the emphasis on "mandatory" participation became unnecessary. Teachers at BIO highlight the importance of continuing the annual Teachers' Retreats after the bioCEED funding period is discontinued. The value of the Teachers' Retreat is also underscored by the high level of participation through the years, with an average of 80% of teaching staff participating.

> *"...Also, the Teachers' Retreats because you are meeting up with colleagues over a relatively long time (at least you are forced to stay with each other over two days, away from UiB) ... that collegial sharing atmosphere is a meaningful thing that bioCEED has started. In one way, we were forced to do it, but then it began to feel natural in the end. I can see a big difference in how we interacted at that first retreat and how we interact now.*
>
> Testimonial by Anne Bjune

Box 2.1. *BIOs Teachers' Retreat.*

series with contributions from educators on current and relevant topics. The Digital Teachers' Meeting program was awarded the UiB work environment prize in 2021[4], and also draws participants from outside of BIO.

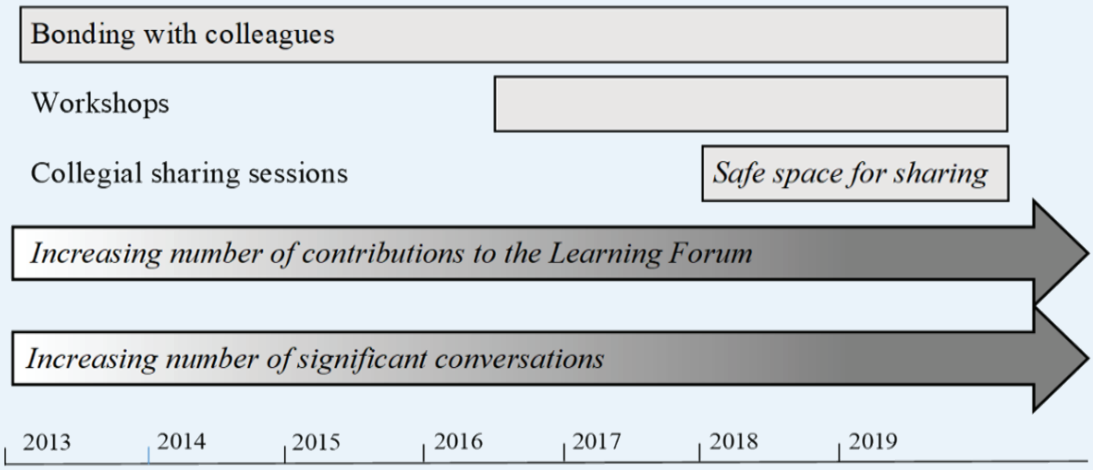
The bioCEED seminars are another example of a low-effort activity, in which educators participate in a seminar with an invited or local speaker. These low-stakes initiatives are designed to make participation easy, but still provide an opportunity to learn more about research-based education and innovative teaching methods. A third example is the sharing sessions during UNIS Learning Forum, which are conversations facilitated by teachers sharing concrete experiences and engage colleagues in informal, yet relevant teaching and learning discussions. By providing these low-commitment activities, bioCEED facilitated informed teaching and learning conversations and community building that create pathways to engagement (Eidesen et al., 2023a). Facilitating conversations between teachers within a study program, like the 100 Club (Box 2.3) has led to the development of Communities of Practice (CoP) (Wenger, 1998).

Learning Forum (LF) started in 2013 as a small voluntary event for scientific staff to increase the attention on educational quality at UNIS. bioCEED became a part of the organizing team in 2015 and has since been instrumental in planning, developing, and running the event. LF has developed and grown in many ways over time (Fig. 2.4), both in terms of the length, number of participants, and the inclusion of all staff members (realizing that all groups contribute to quality in education) – averaging 70 participants annually. The format of the event has evolved, incorporating more interactive elements. LF provides an annual opportunity for staff involved in teaching to focus and reflect on teaching and discuss pedagogy in formal and informal groups.

LF grew to a 2,5-day event from 2015, including departmental meetings and extending invitations to all UNIS staff. Sharing sessions were introduced in 2018, to encourage even more collegial sharing. A **sharing session** is a one-hour session with 5-10 participants that includes a short introduction to a topic followed by a roundtable discussion. Different aspects of participants teaching practice are shared and discussed with colleagues. The sharing sessions have become an essential and valued part of LF and have led to significant informal teaching conversations continuing beyond the event (Eidesen et al., 2023a). At the poster session, introduced in 2020, staff members can present their SoTL work to colleagues.

Students have been involved in LF since 2018, participating in plenary sessions, giving talks, presenting posters, and planning their own LF event with student workshops. Involving students, both as participants and contributors, enhances and fosters a collaborative learning environment at UNIS.

> *"I had little understanding of the point of bioCEED (mainly it was a culture I didn't understand) but over time more understanding developed, knowledge of terms was important, taking part in the Learning Forum at UNIS helped, and meaning became clearer with teaching."*
>
> Testimonial by Simone Lang



Box 2.2. *UNIS Learning Forum. The UNIS LF has grown from a small, voluntary event with 13 participants to a mandatory gathering for all staff. Initially, it was a four-hour lecture-based session for scientific teaching staff, but it has expanded into a broader event for collegial activities, now involving 100 participants. The figure in the box is from Eidesen et al., 2023a.*

The **BIO 100 Club** is a **discussion forum for course leaders** of the six large mandatory biology courses in the Bachelor's of Science (BSc) Programme in Biology. Through these discussions, the BSc degree has achieved better alignment. The 100 Club engages in curriculum development, such as curriculum mapping of skills and content. For example, academic writing, with a particular focus on the IMRaD structure (Introduction, Methods, Results, and Discussion), was identified as an important transferable skill, and through mapping this skill in the BSc courses, the programme was better aligned, and teachers got a better understanding, and a sense of shared responsibility for training academic writing in the BSc degree. As the students' progress through the six core biology courses, each course focuses on a different aspect of the IMRaD structure. The curriculum mapping informed the later process of redesigning the BSc Programme in Biology (the ReDesign Project[5] - Student-active research and transferable skills in redesign of the biology education).

The 100 Club has become a Community of Practice (CoP) (Wenger, 1998), a group of practitioners with a shared responsibility and concern. Initially, each course tended to be separate from the others, with little conversation between the course teachers—a result of tradition, busy schedules, and lack of spaces to meet. Courses were commonly referred to as "my course" and "your course." As the feeling of shared responsibility and trust grew with time, and alignment between the courses became better, we frequently heard statements such as "this is not *my course*, I manage the course on behalf of the department" and "I no longer spend much time on this part of the curriculum, as I know this is covered in other courses."

The 100-club is led by bioCEED and the Head of Education at BIO and will continue after the SFU period.

Box 2.3. *The 100 Club – An example of CoP development.*

bioCEED has developed formal professional development opportunities through our teaching and learning courses. This includes the Teaching Assistant (TA) courses developed at BIO[6] and UNIS[7] aimed at PhDs and MSc students with teaching responsibilities. These courses filled a gap as no such tailored (biology/STEM) offer existed. These courses have been welcomed by the PhDs/TAs, both as a source of pedagogical training and to build a network of peers in a similar role. The BIO TA-course has since 2024 moved to the STEM Education Research Centre (SERC) at UiB and is now offered to TAs at all STEM departments at UiB. The UNIS TA-course is continued by SFU iEarth.

The teaching and learning course MNPED660[8] is a more extensive pedagogical course, where participants conduct a SoTL project in groups that share a common identity or interest. This course was built on a similar course developed at LTH (Andersson & Roxå, 2014), and adapted to the bioCEED context (Andersson & Raaheim, 2017). The course encourages reading, discussing, documenting, and reflecting on themes related to teaching and learning within each group member's context. Course activities facilitate collegial peer review and collegial reading of educational literature and theory. Together, these activities provide a common language that makes collegial reflections on teaching experiences possible. Collegial groups engaging in meaningful and relevant projects address the importance of the local level in developing a collegial teaching culture (Roxå et al., 2008).

In collaboration with SFU iEarth, bioCEED offered the course Leading Educational Change – through SoTL[9] for educational developers and educators within the SFUs in 2021/22. The course focused on change theory, and included group SoTL projects on educational change and development. Box 2.4 describes some of the outcomes of these courses.

The collegial activities have been core to bioCEED's work and priorities. However, we also

acknowledge the need to change systems and structures to truly transform education. To this end, bioCEED has been active in the public and sectorial debate[10] through committees, hearings, and op-eds (bioCEED 2014-2023). We have been an advocate for a scholarly approach to teaching and learning, research-based education, student partnerships and evidence-based teaching and assessment.

bioCEED has worked with our institutions to improve quality assurance systems, ensuring a continuous focus on improving all educational activities. Student course evaluations are an important backbone in quality systems. At BIO and UNIS course evaluations have undergone extensive revisions, with bioCEED support, leading to a practice focusing on student learning rather than student satisfaction. The improved course evaluations include validated survey items from the Course Experience Questionnaire (CEQ) and the Constructive Alignment Learning Experience Questionnaire (CALEQ)[11].

Since 2018, bioCEED has participated in the UNIS Educational Committee (ECom) which oversee educational quality. This close collaboration between the institution and bioCEED have ensured a crucial developmental focus. bioCEED has contributed useful tools for educators while developing their courses. For example, the research based student workload calculation sheet[12] enables educators to understand and calculate student workload when revising or planning courses. The tools are an open online resource, also used by other higher education institutions. bioCEED collaborated with Academic Affairs and scientific staff at UNIS to create an institutional policy and system for PhD duty work at UNIS, improving and professionalizing the allocation of PhDs teaching hours as a teaching resource.

bioCEED was leading in Norway in developing a pedagogical reward system in Norway that acknowledges and rewards academic teachers that systematically develop their teaching to support student learning. Within this pedagogical reward system academic teachers can apply to have their pedagogical competence assessed towards a set of SoTL-based criteria. Successful applicants get the title *Excellent Teaching Practitioner (ETP)* and become members of the Faculty's Pedagogical Academy[13] (Førland et al., 2017).

In 2018, bioCEED co-hosted (with UPED, UiB) the conference of the International Society for the Scholarship of Teaching and Learning – ISSOTL2018 (Fig. 2.4), bringing more than 666 SoTL scholars from around the world to Bergen and Norway.

Figure 2.4. *Logo of the ISSOTL2018, titled "Toward a Learning Culture", co-hosted by ISSOTL, bioCEED and UPED in Bergen, October 2018.*

bioCEED's effort to disseminate and communicate our approach and results has been extensive and well-documented (bioCEED.no, bioCEED 2014-2023, cristin.no 468879). Outreach has been a priority and focus area in bioCEED, equal to that of Learning Culture, Innovative Teaching and Practical Training. In the following section, we use some of the data from our 10 years of bioCEED outreach activities to show the development of a collegial learning culture.

Impact and outcomes: Multiple pathways to engagement – going public

We have used our outreach records from annual reports 2014-2023 to investigate levels of engagement and dissemination (locally, institutionally, nationally, and internationally, Fig. 2.5), the target audience (Fig. 2.6), and who has disseminated on behalf of bioCEED (Fig 2.7, 2.8 and 2.9). The outreach records from the 10 years of bioCEED activity include events/dissemination activities hosted by bioCEED, invited contributions by bioCEED and associates, as well as contributions to national and international teaching and learning conferences (Tab. 2.1). These contributions show *some* of bioCEEDs dissemination activities. bioCEED's outreach activities have also included more than 40 published scientific publications and 28 scientific conference papers[14] on teaching and learning, and several posters[15]. More than 20 Master theses and 4 PhD theses[16] have been written with – or about - bioCEED. In addition, bioCEED also contributed to podcasts, news items, op-eds, reports and hearings (bioCEED annual reports 2014-2023). Note that activities with *students* as the main speakers or target audience are not included here but are reported in the Students as Partners chapter.

Table 2.1. *Overview of outreach activities in different venues used to show development over 10 years.*

OUTREACH VENUES	Total	Local	Institutional	National	International
bioCEED seminars	130	63	56	9	2
Invited talks/workshops	299	4	143	127	25
Scientific conferences	113		2	48	63

The figures below show two "dips" in outreach activity. The first, in 2018, we claim is a result of lower activity in 2017 during the mid-term evaluation of bioCEED – and thus less results to disseminate in 2018. In addition, much effort and resources were allocated to host the international conference ISSOTL2018, also impacting the broader outreach activity. The second dip is due to the covid-19 pandemic and the restriction that impacted the entire society – including Higher Education. An interesting feature of the data from this period, is that bioCEED managed to maintain – and even increase – the local and institutional outreach, supporting educators and students during a challenging time of transition and adaption of teaching following restrictions and pandemic challenges.

When we break levels down to target audience (Fig. 2.6), we see that academic teachers have been the main target audience throughout the 10-year period. Outreach targeting educational developers and researchers has increased as bioCEED has had more results to report, and fluctuates with the larger events that gather an educational developer/researcher audience like the large national and international conferences (e.g. MNT and ISSOTL conferences).

Although it is satisfying to see that bioCEEDs dissemination have reached far and wide – and that we have maintained and increased these efforts during our SFU-years, the most important aspect – in particular when we use these data to document *cultural change* – is perhaps who is doing the talking? Are the speakers and facilitators a more diverse group now than ten years ago? Have more educators beyond the core team gone public with their teaching and learning development and practice?

When we break down the data to individuals contributing, we find more than 203 different

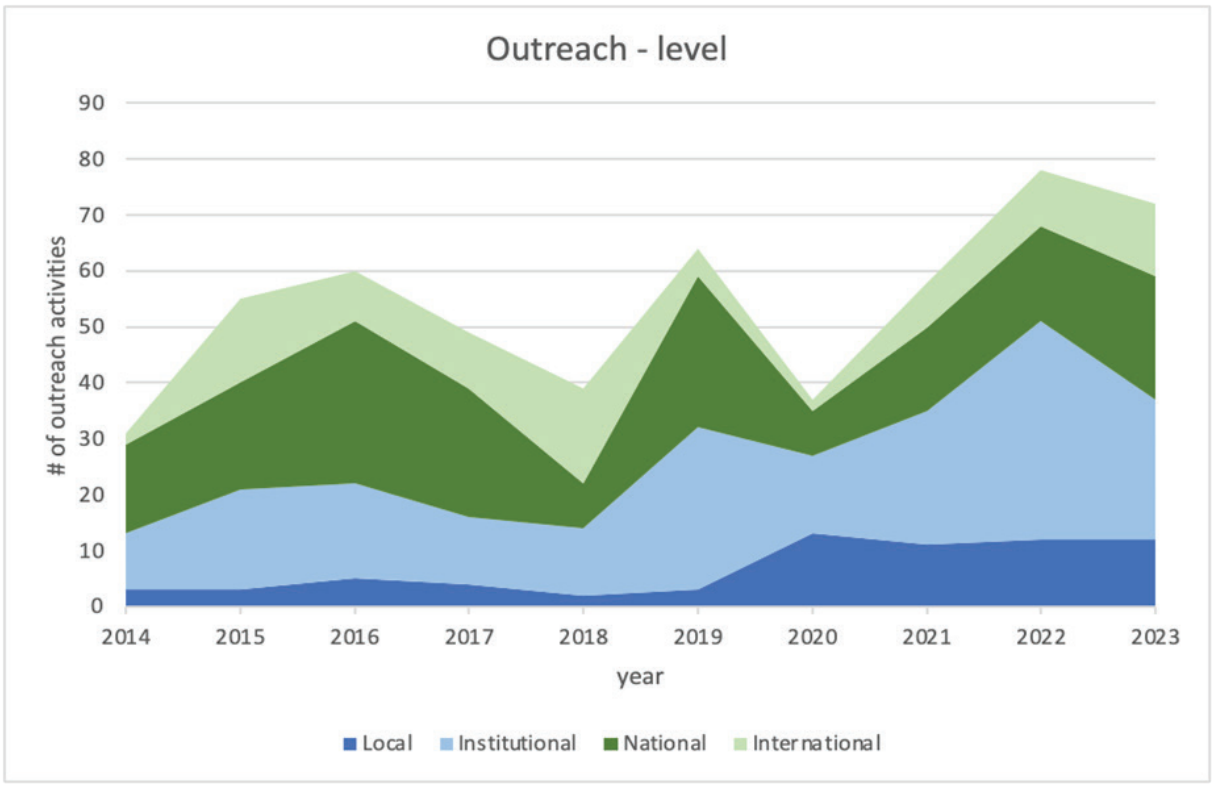


Figure 2.5. *bioCEED outreach (N=549) on different levels. Local outreach include activities at the partner departments (BIO and AB). Institutional level outreach is open activities that include audience outside the biology departments (e.g. UNIS and UiB). The national and international level include outreach outside our partner institutions. Note that one activity in 2013 is included in the 2014 numbers (1/31), and six activities in 2024 included in the 2023 numbers (6/72).*

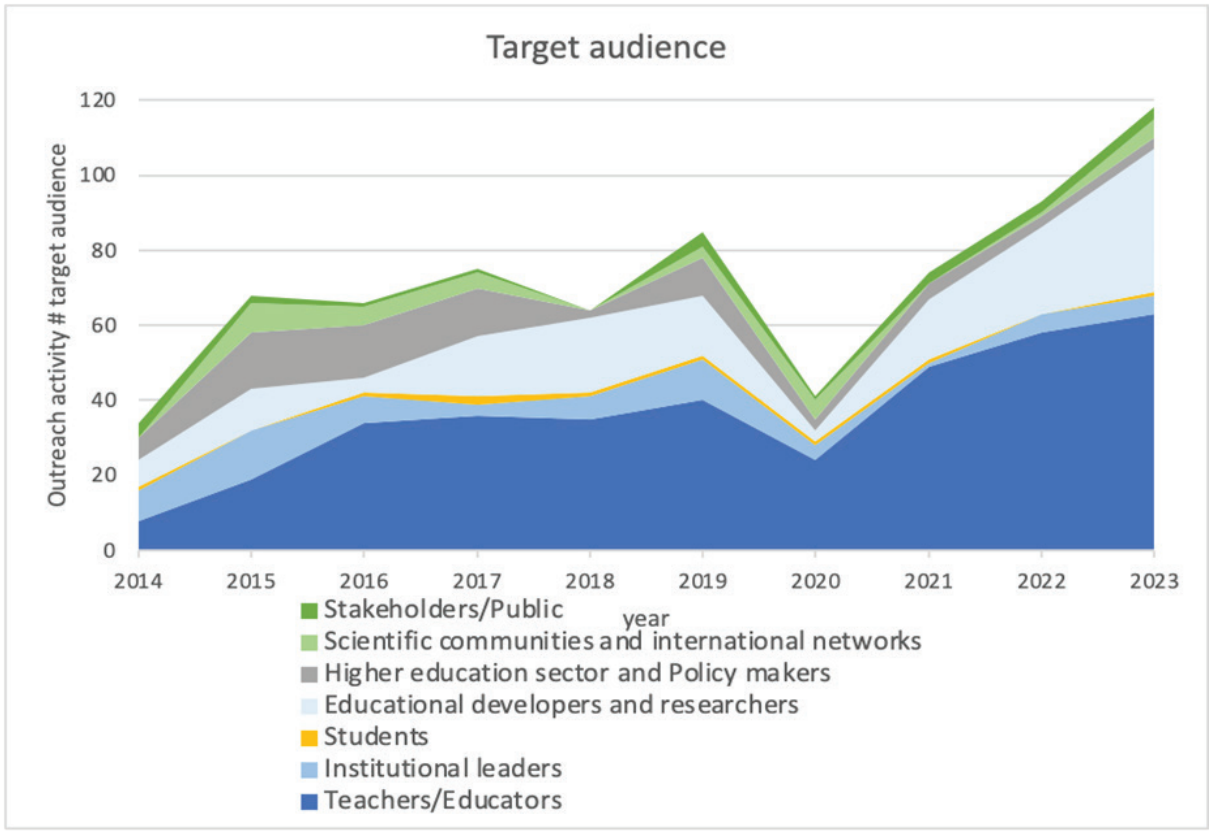


Figure 2.6. *Target audience. Note that some outreach activities have more than one target group. Also note that one activity in 2013 is included in the 2014 numbers (1/31), and six activities in 2024 included in the 2023 numbers (6/72).*

individuals over 10 years, with the modest number of 13 individuals in 2013/14 growing to 80 in 2023/24. Also, we see that the percentage of contributions from students and student partners increase significantly as we enter the second phase (2019-2023). Note that this increase is in outreach where students are not the main target audience (Fig. 2.6), rather, it shows students doing outreach to educators and higher education at large.

The multiple pathways to engagement are reflected in the multiple voices speaking on behalf of bioCEED through the years. While the core team has contributed steadily throughout the centre period, the percentage of individual contributions shows a steady increase in teachers/educators and external collaborators' dissemination, often in partnership with core team members. These are teachers and educators collaborating on projects, taking part in SoTL projects or invited to share experiences in seminars. These multiple pathways to engagement enable educators to contribute at different levels, and to engage in scholarly and collegial discussion of their practice, projects, findings and experiences to different audiences locally, institutionally and internationally.

Conclusion

The outreach data we have presented shows that involvement beyond the core team and "coalition of the willing" have increased over these 10 years. The data we presented represent both committed and sustained involvement (e.g. presenting your SoTL project at a conference implies you have done a SoTL project), and other more low-commitment involvement (e.g. sharing and discussing at sharing session).

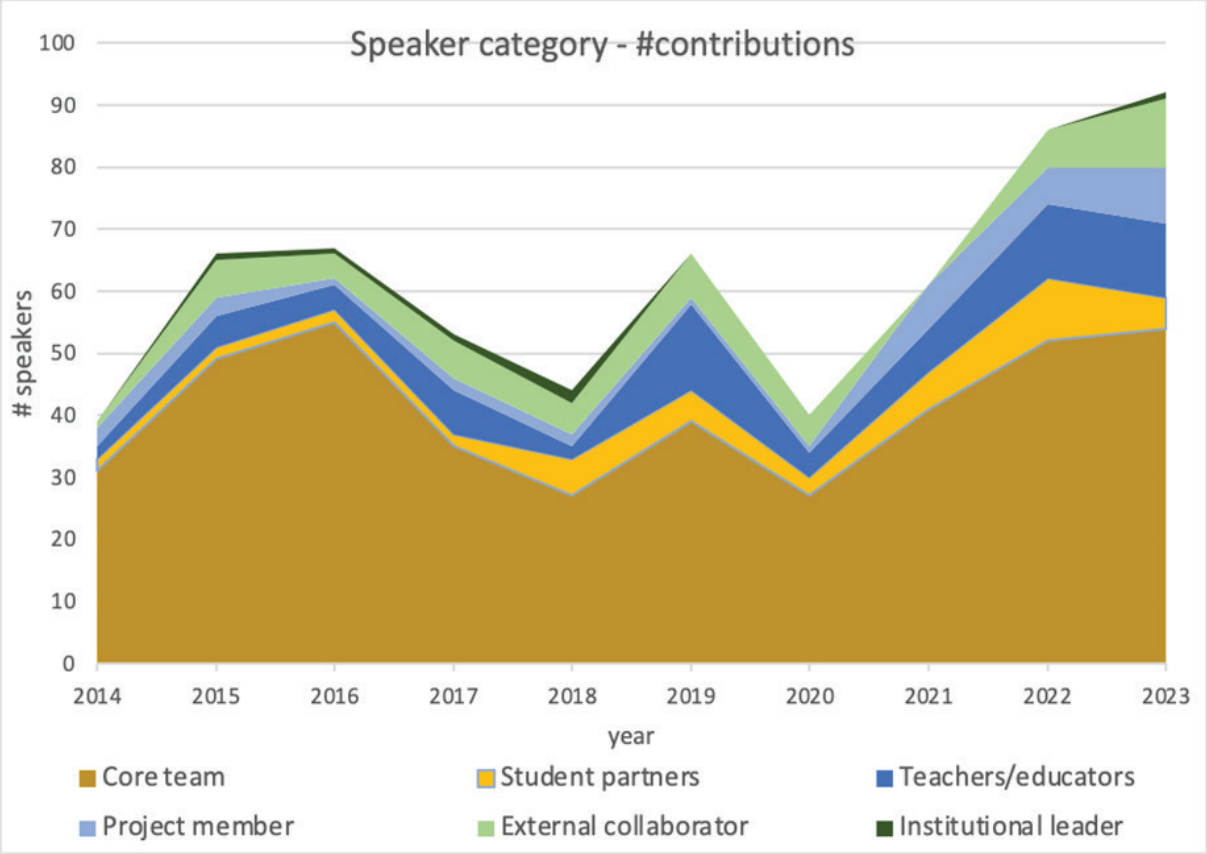


Figure 2.7. *Speakers/facilitators by category. The core team refers to bioCEED staff, Student partners include students working in or with bioCEED, Teachers/educators include academic teachers and other educators, project members are mainly educators or researchers that contribute on specific projects associated with bioCEED, external collaborators refer to external (outside our institutions) experts, researchers, educational developers, and sector representatives. Note that one activity in 2013 is included in the 2014 numbers (1/31), and six activities in 2024 included in the 2023 numbers (6/72).*

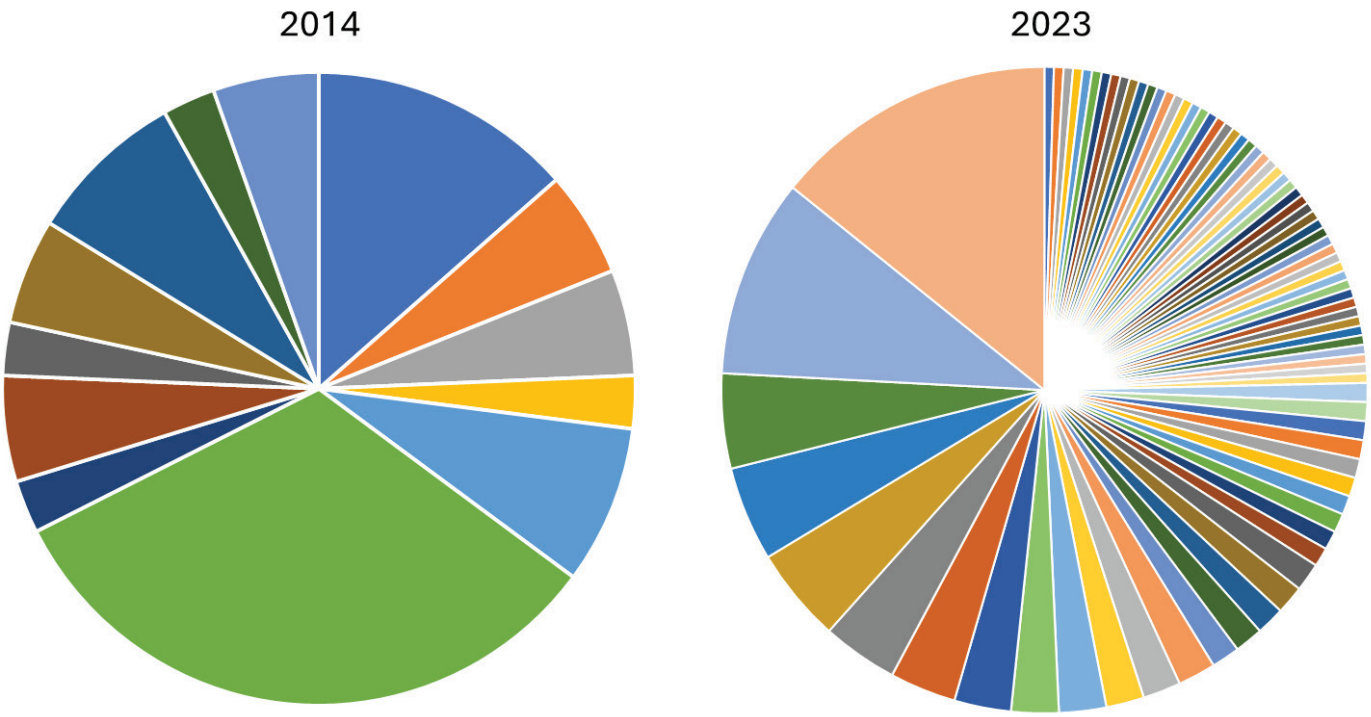


Figure 2.8. *Individuals speaking – each cake piece is one individual, 20(13/)14 (N=13) vs 2023(/24) (N=80). 2023: bioCEED core team more often have repeated contributions (e.g. the larger cake pieces), while teachers and collaborator more often have one or two contributions. Note that one activity in 2013 is included in the 2014 numbers (1/31), and six activities in 2024 included in the 2023 numbers (6/72).*

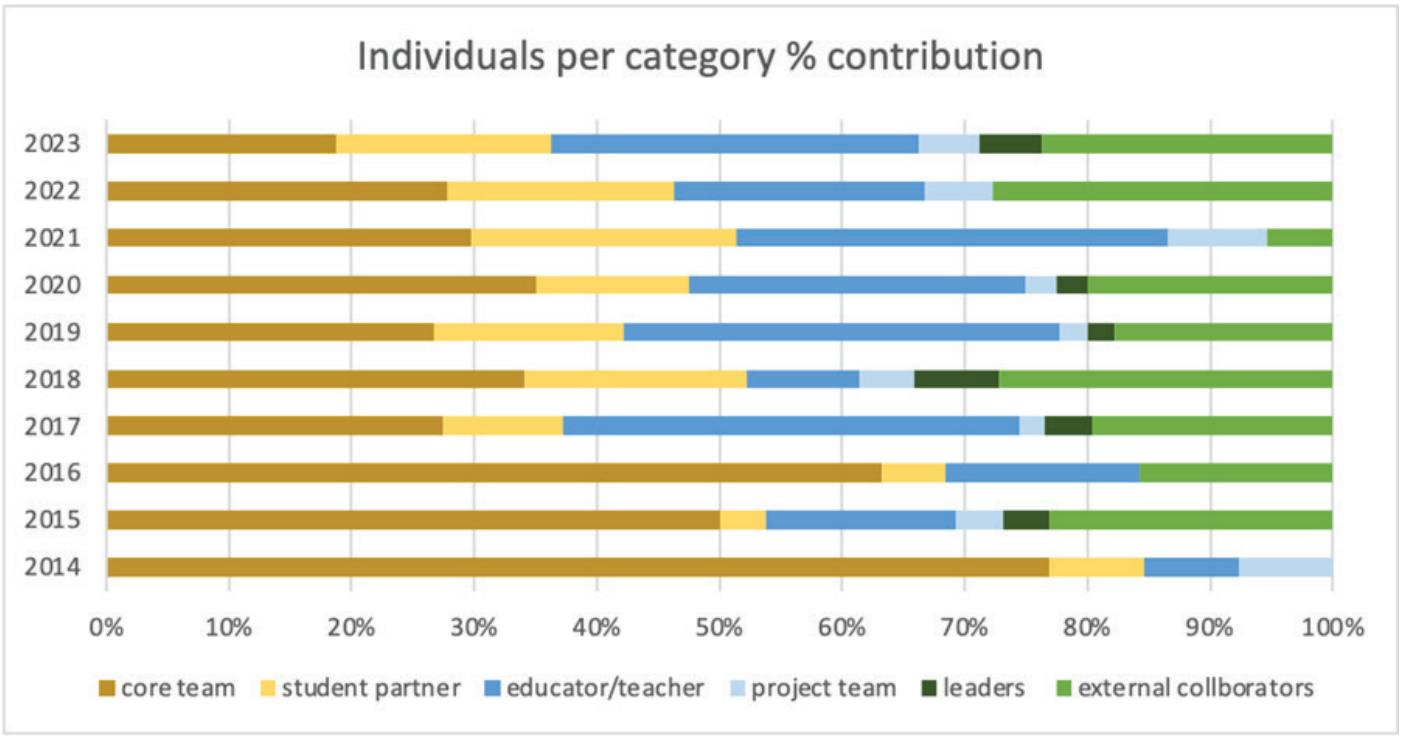


Figure 2.9. *Individuals contributing per category in %. Note that many activities have more than one contributor. Also note that one activity in 2013 is included in the 2014 numbers (1/31), and six activities in 2024 included in the 2023 numbers (6/72).*

We similarly see increasing involvement at our institutions over time. In sum, we see these results as a sign that we have come far towards a collegial and scholarly learning culture at our departments, and that we have inspired educators, students and leaders beyond our departments and institutions.

Based on what we have learned these ten years of supporting a cultural shift towards a scholarly and collegial teaching and learning culture, we encourage educational developers, leaders and educators to consider the following ten points in "the bioCEED list" for supporting a cultural shift:

1. Ask the right questions:
    - What needs to change? (tip: culture).
    - What do we need to know? (tip: gather data, ref. #3).
    - Where do we start? (tip: bottom-up).
2. Bring together the often separate academic cultures - research and teaching, to make teaching a collegial, peer reviewed and documented activity. "*Bring your researcher head into the classroom*." Support teachers and student in teaching and learning projects (tip: SoTL).
3. Gather information, data, and documentation– be *knowledge based and scholarly*.
4. Define common goals (e.g. the bioCEED triangle, more active learning).
5. Educational leadership (captain, champion) (tip: listen at the bottom, talk at the top).
6. Include, involve, and inform all relevant groups (see Fig. 2.2).
7. Develop a common language (pro-tip: start by reading the same book).
8. Create collegial activities (tip: aim for diversity, see Fig. 2.3).
9. Partner with students (tip: student led projects).
10. Recognize and reward teaching (tip: Pedagogical Academy) – *influence institutional structures*.

MNPED660[17] and **Leading Educational Change Course** have more than 120 educators completing the course (largest group are professors/associate professors, but also study admin, library staff, PhDs, researchers, technical staff) – across (STEM) disciplines.

The course participants have completed a total of 37 SoTL group projects. These projects have added to our knowledge about teaching, learning, assessment, and learning outcomes at our departments. As a result of these projects, we now know more about our courses, programs, students and staff (e.g. Bjune et al., 2017; Keers et al., 2017; Enberg et al., 2019; Damsgård et al., 2017). The SoTL projects have formed the first step towards developing learning resources (like bioSTATS[18] (Eliassen et al., 2017) and bioWRITE[19] (Andersen et al., 2017)) - and later projects have investigated the use and usefulness of the resources leading to further development. SoTL projects have also developed new ways of teaching (e.g. Gya et al., 2019), and new procedures/tools for course design (e.g. Soule et al., 2017; Våge et al., 2019). The projects have all be presented locally, following the learning objective of going public. In addition, more than 20 of these projects were presented at national or international teaching and learning conferences (e.g. MNT-konferansen). Presenting the SoTL project at peer-reviewed teaching and learning conference has an added value for the participants, adding relevance, giving inspiration, and increased confidence to discuss teaching and learning in a broader community (Førland & Andersson, 2021).

Box 2.4. *Professional development through collegial and scholarly projects (SoTL).*

List of hyperlinks used in this chapter

2. bioCEED 2014-2022: https://bioceed.w.uib.no/annual-reports/
3. toolkit: https://bioceed.w.uib.no/resources/toolkits/toolkit-cpc/
4. work environment prize in 2021: https://bioceednews.w.uib.no/2022/05/30/bioceed-and-bio-receive-the-university-of-bergen-work-environment-award-for-the-initiative-with-digital-teachers-meetings/
5. the ReDesign Project: https://bioceed.w.uib.no/redesign/
6. BIO: https://bioceednews.w.uib.no/2021/03/10/pedagogical-ta-course-is-here-to-stay/
7. UNIS: https://bioceednews.w.uib.no/2022/05/13/teaching-assistant-course-at-unis-runs-for-the-second-time/
8. MNPED660: https://bioceed.w.uib.no/resources/toolkits/toolkit-cpc/
9. Leading Educational Change – through SoTL: https://bioceednews.w.uib.no/2022/05/15/leading-educational-change-through-sotl-final-session-at-unis/
10. in the public and sectorial debate: https://bioceed.w.uib.no/outreach/bioceed-in-the-media/
11. Constructive Alignment Learning Experience Questionnaire (CALEQ): https://bioceed.w.uib.no/resources/toolkits/toolkit-student-surveys/
12. student workload calculation sheet: https://www.unis.no/wp-content/uploads/2022/11/guideline-on-calculating-student-workload.pdf
13. Faculty's Pedagogical Academy: https://www.uib.no/pedagogiskakademi/mn
14. 40 published scientific publications and 28 scientific conference papers: https://bioceed.w.uib.no/outreach/scientific-publications/
15. posters: https://bioceed.w.uib.no/posters/
16. 20 Master theses and 4 PhD theses: https://bioceed.w.uib.no/theses/
17. MNPED660: https://bioceed.w.uib.no/resources/toolkits/toolkit-cpc/
18. bioSTATS: https://biostats.w.uib.no/
19. bioWRITE: https://biowrite.w.uib.no/

3. Students as Partners

Tina Dahl, Kristin Holtermann, Oddfrid Førland & Sehoya Cotner
with valuable contributions from the core team and student partners

When bioCEED became a SFU in 2014, student involvement was a crucial part of the centre's plan and the rationale for the SFU status. Our initial, somewhat naïve, notion of what student involvement meant, has evolved gradually over the 10 years into a systematic practice of student partnership (Nerlie & Førland, 2023). *Student partnership* differs from mere *student involvement* in that students are not only "heard" and "represented", but rather included in a mutual collaboration in which all participants can contribute in various ways to the development, implementation, analysis, and decision-making within teaching and learning (Cook-Sather et al., 2014). The essence of student partnership is that students, in collaboration with staff, can meaningfully contribute to the development and enhancement of the teaching and learning experience (Mercer-Mapstone et al., 2017). This collaboration can also take the form of co-creation, whereby students are active participants in creating their own learning process and activities in their courses (Bovill et al., 2016).

The gradual shift in approach from student involvement to student partnership was summarized by bioCEED board leader Yael Harlap at the bioCEED 10-year anniversary seminar (UiB, March 6th 2024):

> *In the SFU application in 2013, the word "partners" was used for consortia partners, not for students. The first appearance of the concept of "Students as Partners" was in the annual report 2015 – part of a title of a workshop that bioCEED contributed to. In the 2016 annual report the concept of partners was used mostly about external partners, but:*
>
> *"At the core of bioCEED's work is the realization that education, and educational quality, is a collegial responsibility. While each individual student is fundamentally responsible for his or her own learning, and while each individual teacher is also fundamentally responsible for the content and quality of the courses they teach, the overall responsibility must be shared in a collegial way. Furthermore, students and teachers are not the only 'players' in the educational 'game', technical and administrative staff, course assistants, educational developers, and the departmental and institutional leadership are all part of the partnership that together shape the content and quality, both in terms of the subject matter and pedagogy, of our courses and programs" (bioCEED, 2016).*
>
> *In the 2017 report it says, "A key success criterion is involving Students as Partners in educational development and assessment of success." External partners are no longer described simply as "partners" but as "external partners" and the term "Students as Partners" is used in a number of places. Under organization and management: "Students are involved as active and responsible partners." "Student and stakeholder involvement in bioCEED is already strong; they participate in leadership and management, and as co-creators of and active participants in our R&D projects, panels, meetings, and innovations" (bioCEED, 2017).*

The framing of the 2018 report starts as follows: "bioCEEDs greatest pride, and arguably also our greatest achievement, is the strong and productive collegial culture that has grown amongst our staff and students during our time as a centre." The opening continuous to describe co-creation, co-management, and co-leadership with students across many activities. Subsequently, the report continues with:

"This broad involvement in general, and the student initiatives in particular, have led us to question the very name of Focus Area 1, Teacher culture, which seemed so appropriate only a couple of years back. Now it feels oddly outdated and narrow, and we ask: Is 2019 the year when bioCEED renames this focus area A Learning Culture, to reflect that the learning partnership involve the full breadth of students and educational staff within and beyond higher education programmes and institutions?" (bioCEED, 2018).

And the term "Students as Partners" is used broadly throughout. In 2021 annual report the action point is revised as part of the changing understand of what students are:

"As we are learning and developing as a centre, we see the need to change the language we use to describe our work involving students. Therefore, we have revised the Action (A15) to embrace a students-as-partners perspective rather than student input-perspective: Outdated text A15: Establish student panel to advise development of innovative teaching modules and curricula. Revised text A15: Involve students in all research and development activities and projects. Involve students in decision making. Ensure sustainability and learning outcomes and provide fair working conditions for student partners" (bioCEED, 2021)

Yael Harlap, in a speech at the bioCEED 10-year anniversary, March 2024

So, what have been the key factors for this change in perception and understanding of Students as Partners?

In 2016, NOKUT offered additional funding for student-led projects within the SFUs. This grant inspired bioCEED to allocate additional funds for student-driven educational development projects, whether it be at the centre, program, or course level. The purpose of the incentive was to integrate students more into the academic community, while also encouraging them to take ownership of developing and shaping their own education. The grants were intended to support student learning through collaboration between students and staff (student partnership). bioCEED student representatives developed grant proposals for what became the student-led projects biORAKEL[20] at BIO and UNISbreakfast[21] at UNIS (Fig. 3.1). These initiatives were led by students, and offered students a supportive community with peers that enhanced the learning environment.

Figure 3.1. *Logos of the two student-driven projects biORAKEL (left) and UNISbreakfast (right).*

The biORAKEL proposal was linked to one of bioCEEDs initial objectives to establish an oracle service where "PhD students could teach and advice students withing topics in which they are experts" (UiB 2013, WP Learning environment; A11 Develop student spaces). The bioCEED core team had

Figure 3.2. biORAKEL was awarded the Learning Environment Prize at UiB in 2018. (Photo: Jens H Ådnanes).

not succeeded in establishing this activity, until biORAKEL[22] was developed by the students in 2017. The concept was later implemented and developed at UNIS (UNISoracle) as a forum for BSc students in biology to discuss and reflect on topics from their courses, while also developing transferable skills. In this setting, BSc students work with help from MSc and PhD students on creating presentations, designing posters, and practicing their presentation skills.

biORAKEL represented something new, where students had ownership and responsibility, not only to initiate, but also to organize and run the project. biORAKEL offers weekly meetings for students where students work together and help each other. Fortified with waffles and coffee, students can attend and be part of the student community, and this in turn can increase student motivation to engage in their courses (Gya & Bjordal, 2017). In 2018, biORAKEL was the first student-led project to receive the UiB Learning Environment Price[23] (Fig. 3.2).

At UNIS, UNISbreakfast was established by the BSc students to address the need for community building among BSc, MSc, and PhD students in the AB department at UNIS. It later expanded to include students from all four scientific departments, creating a more interdisciplinary informal community for learning and collaboration. At UNISbreakfast, MSc and PhD students present their research, share the challenges they have faced, and reflect on the academic decisions that shaped their paths. Breakfast is served during the presentations, fostering a relaxed and friendly atmosphere that encourages informal learning and networking among students.

For bioCEED, the establishment of biORAKEL and UNISbreakfast was a turning point, when we learned that often those most qualified to develop and lead a project are not the teachers, staff, or leaders, but the students themselves. This realization led to a deeper understanding of how to involve Students as Partners, resulting in a diverse portfolio of student-led projects within bioCEED.

The two podcasts with student partners Pernille Eyde Nerlie and Ruben S. Thormodsæter describe the student-led projects and give a student perspective on student representation and student partnership in bioCEED (Kvalitetstid[24] podcast with Pernille Eyde Nerlie from 2021 and NOKUT podcast nr 60[25] with Ruben S. Thormodsæter from 2024).

From the beginning, the student representatives gave important feedback and added to initiatives and project development. As students became more involved with bioCEED, and their responsibility and commitment increased, it became evident that their efforts deserved more recognition. Since 2019, the employed student partners in BIO formed the learning community bioHIVE, in partnership with bioCEED staff. bioHIVE[26] supported the student partners in the various projects and ensured alignment with bioCEED and partner priorities. bioHIVE facilitated collaboration across projects, ensured progress and increased sustainability and support for student partners and projects. The student partners reported that the bioHIVE community was rewarding, and by being a group the student partners could amplify each other's voices. Acknowledging and rewarding students for their significant contributions, and providing structure and support, has been instrumental in achieving true partnership.

Developing a scholarly approach to student partnerships has been a process, where staff and students have informed themselves through multiple workshops that explored and expanded upon the concept of Students as Partners and methods for engaging students more actively in partnership and co-creation. However, as early as 2017 students were taking a leading role in talking about student engagement and involvement (Gya & Bjordal, 2017[27]).

In 2018, bioCEED hosted the international ISSOTL conference in Bergen, and students were key to the success of the conference (Fig. 3.3), not only because students helped organize the conference, but also because bioCEED student partners played an important part in the opening keynote[28], and gave the well-attended workshop Challenges and Benefits in Involving Students as Partners to Improve Teaching and Learning Culture [29] (Bjordal & Lygre, 2018).

Figure 3.3. *Student partners Ragnhild Gya and Mari Bjordal at the ISSOTL 2018. (Photo: bioCEED).*

Since then, students have participated in numerous events to promote the significance of Students as Partners where they have shared scholarship and experiences with diverse audiences, including students, educators, the higher education sector, and policy makers. For example, Pernille Eyde Nerlie was part of an invited keynote to the NOKUT Conference in February 2024, focusing on building effective student partnerships in support of education research and development (Fig. 3.4).

Multiple pathways to partnership and co-creation

Students have engaged in bioCEED in a variety of ways, with a gradual shift from a few students acting as consultants to students being increasingly engaged, with extensive agency and ownership of projects and outcomes.

According to Healy et al.'s (2014) conceptual model of student as partners, students' engagement and partnership can be described as four interrelated areas: Learning, teaching and assessment; Subject-based research and inquiry; SoTL; and Curriculum design and pedagogic consultancy. In a bioCEED context the partnership areas can be described as Learning, Teaching and Assessment; Authentic Research Experiences; Educational Development and Research; and Curriculum and Course Design (Fig 3.5). bioCEED student partners have co-developed and co-researched biology learning and learning environments. This involvement includes participating as co-researchers on research projects, as well as co-developers on educational quality enhancement and curriculum design.

Figure 3.4. *Pernille Eyde Nerlie addresses over 650 participants at the NOKUT annual meeting in Oslo, February 2024 (Photo: Kari Bjørgo Johnsen).*

Figure 3.5. *A conceptual model of student partnership in bioCEED. Adapted from Healy et al. (2014). The outer circle shows examples of activities and projects where students were partners, co-creators, and co-researchers.*

The broader student community at BIO and AB has benefited from bioCEED's educational development, as more courses have introduced active learning and elements of co-creation (e.g., the student poster symposium[30]) – giving students agency and empowering them to shape their own learning experiences. bioCEED efforts have significantly increased our biology students' opportunities to gain authentic research experiences and research skills training. This is evident from various initiatives including the course-based research experiences (BIO299[31], AB-207, see chapter on Practical Training), co-created learning resources by students and staff (such as Teach2Learn[32]), and student-led initiatives like the Student-led Conference on Polar Environment (SCOPE[33]).

The student-led project portfolio grew from the initial projects biORAKEL and UNISbreakfast, to now include the student-led conference SCOPE[33], a student journal (Bikuben[34]), student research experiences through bioSPIRE and UNiSprout[35] and student-developed pedagogical escape rooms[36] (see Box 3.2). Additionally, student partners have created a portal gathering our student resources and offers[37], many of which are co-created by students and staff.

How did you initially become involved in bioCEED? What motivated you to engage?

bioCEED was looking for Student Representatives during my previous semester at UNIS and I wanted to be active in an institution which is trying to improve learning for the students. Also, I wanted to work with the staff involved at UNIS.

What have you done with bioCEED that you consider meaningful?

I did the mid-term evaluation with the biology students. I think it is a great option for students to say what needs improvement and what is already going well. That way the teacher can optimise lectures prior to the exam, the students don't have to wait to give feedback until the end and the learning outcome gets maximised.

Additionally, I was part of UNIS breakfast (in collaboration with iEarth), which is an event taking place several times throughout the semester. It is great to give students more perspectives what one can do and that it is fine to not have a straight career path. It is an opportunity to learn from other students (or PhDs). Furthermore, UNIS breakfast events give insights in non-study subject related topics. iEarth will continue those events.

What impact has this engagement had on your current work? What do you anticipate it might change for the future?

I have always liked networking but getting some further insights was helpful to narrow down future career paths.

Box 3.1. *Testimonial from Sarah Frericks (2024), bioCEED student representative, 2023, UNIS.*

How did you initially become involved in bioCEED? What motivated you to engage?

I became involved in bioCEED through my idea of using gamification in education. I was encouraged to contact bioCEED by some students in biORAKEL—that was the first time I heard about bioCEED. Obviously, I also knew Sehoya from the internship (through the PFTC project and its associated internship program). The initial contact was literally me knocking on Oddfrid and Kristin's door and that was to advocate for using escape rooms as a concept for learning... maybe in March 2021. I remember you and Oddfrid encouraged me to think about learning outcomes and pedagogical goals. And then I got the mini-grant and had a contract to develop an escape room for BIO250 with Anne Bjune.

What have you done with bioCEED that you consider meaningful?

Maybe the main thing that I have contributed with might be showing Sehoya and the rest of the bioCEED core that gamification is a thing that might work in education. I remember some skepticism in the beginning...but still encouragement. You needed me to have a more focused plan, but you never hindered me in any way, and you trusted me. The best thing that bioCEED did for me was to trust me and give me time to do what I thought was right. In the end, we had a physical escape room—

both at UiB and at UNIS. Even though I didn't create the escape room at UNIS, I was part of that as well through us having a workshop at the Learning Forum there in 2022. The domino effect... that is what I see. I understand that better. Having these workshops helped to create something bigger.

***Box 3.2.** Testimonial from Ruben S. Thormodsæter (2024), student partner 2021-2022, BIO.*

Students are partners in curriculum design and educational development. E.g., in the ReDesign project[38], students were part of shaping the curriculum, while also working with assessment, quality assurance and documentation. Other initiatives include the mid-term evaluation at UNIS (Box 3.1), the project Development, testing and evaluation of tools and assessment forms that promote course alignment in field and lab teaching (FieldPass project)[39], and documenting students' experiences with Team-Based Learning (TBL) (Kawousi & Barry, 2023). Student partners contribute to creating a better learning environment, e.g. student active learning spaces at UNIS[40], and developing digital learning resources (e.g. Learning Arctic Biology platform[41] and instructional videos[42]).

Students going public with teaching and learning

bioCEED student partners, representatives and co-creators are part of the collegial and scholarly learning culture at our departments. The scholarly approach also implies going public with teaching and learning in our community and beyond.

Students address audiences on many different levels (Fig. 3.6, Tab. 3.1), including within their departments locally (BIO and AB), beyond their departments at an institutional level, and at a national and international level. According to our outreach records, students have been speaking at

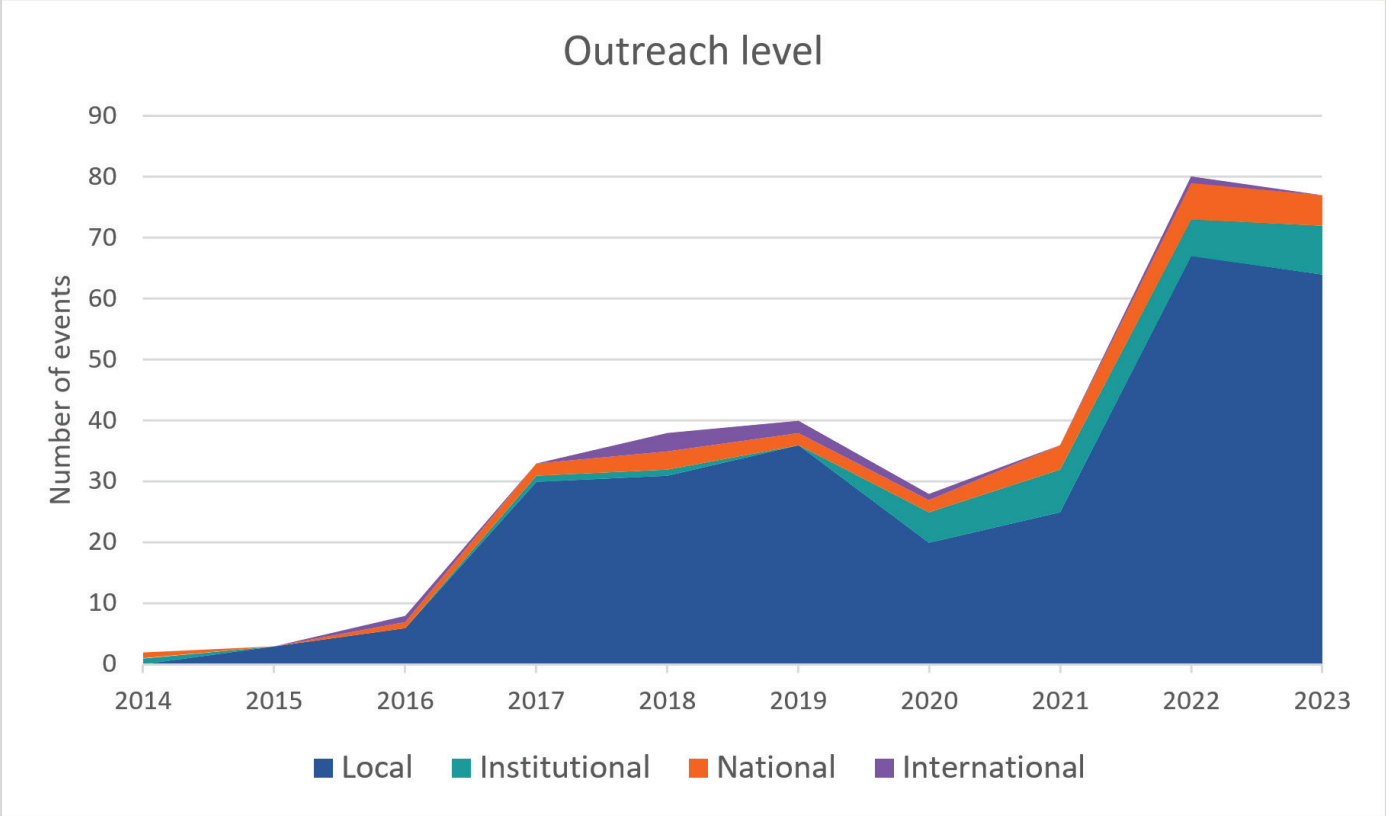


***Figure 3.6.** Student outreach (n=345) on different levels of target audience. Local outreach includes activities at the partner departments (BIO and AB). Institutional level outreach is open activities that include target audience outside the biology departments (e.g. UiB and UNIS). The national and international level contains outreach outside our partner institutions, either within Norway or beyond.*

345 outreach events during the 10-year period. Through the years the student voice has grown from a handful of events during the first years, with a sharp increase from 2016 and forward. In 2020, the onset of the covid-19 pandemic decreased the overall outreach, but since 2021 the number of events were on the same level as before, rapidly growing, culminating in a peak of nearly 80 events in 2022.

As seen in Figure 3.6 and Table 3.1, students predominantly address local audiences, often in their respective departments, and peer students have consistently been the main target audience (Fig. 3.7). However, their outreach at institutional, national, and international levels has increased steadily over time, particularly on the institutional and national level. We also see a change towards a more diverse target audience from the first bioCEED years (phase one 2014-2018) compared with later years (phase two 2019-2023) (Fig. 3.7).

Table 3.1. *Total student outreach on different levels of target .*

	Number of outreach activities
Local	282
Institutional	26
National	29
International	8
Total	345

Students disseminate through diverse channels, from peer mentoring through biORAKEL and UNISoracle (local student-led initiatives), to talks and workshop at various events beyond the local level (Fig. 3.8). Students contribute to national and international conferences with presentations, workshops, panel discussions and as invited keynote speakers (see bioCEED annual reports, bioCEED, 2014-2023). From 2021, the learning community bioHIVE facilitated regular discussion-based meetings which is shown clearly in Figure 3.8.

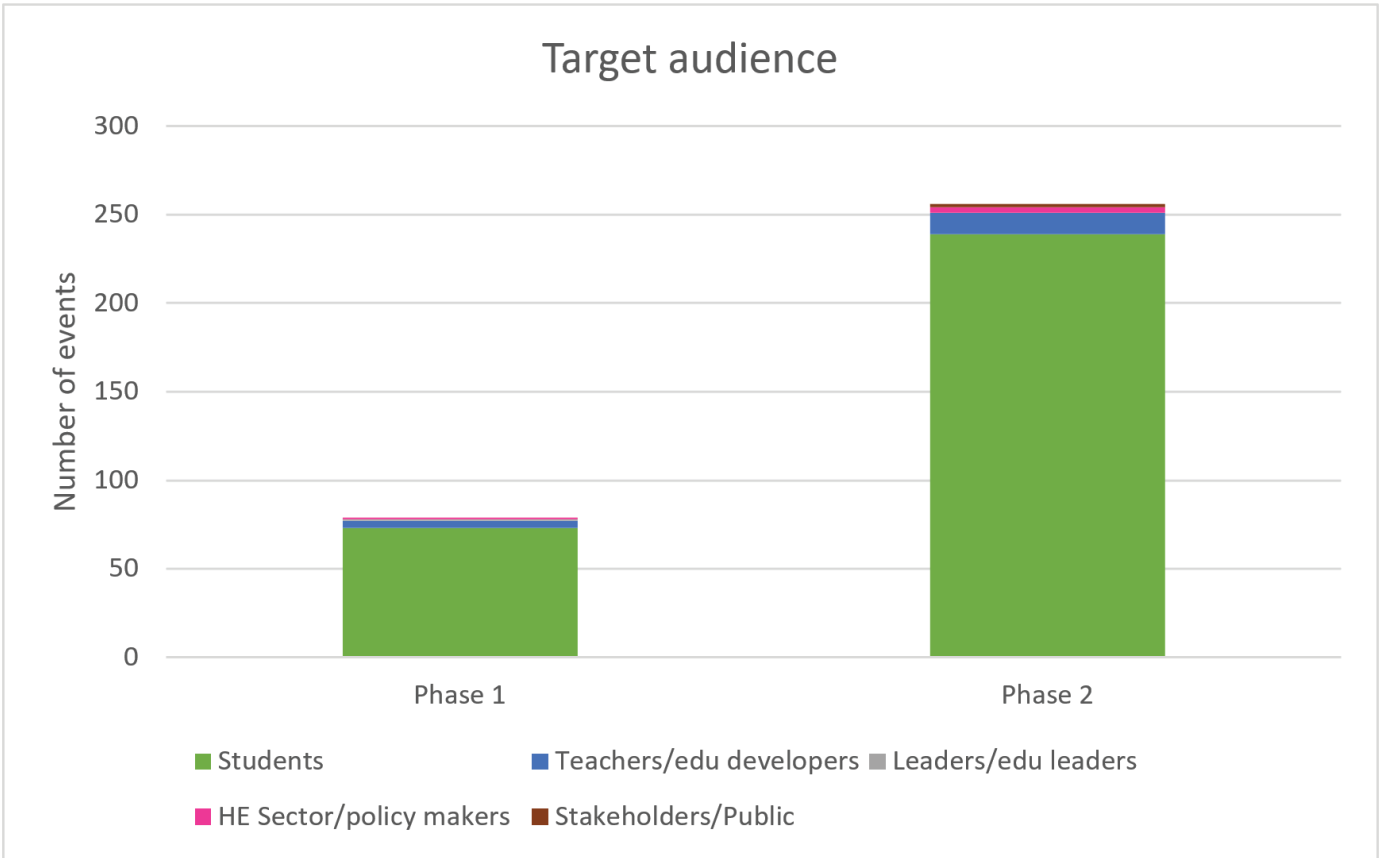


Figure 3.7. *The students' target audience divided into phase one (2014-2018) and phase two (2019-2023).*

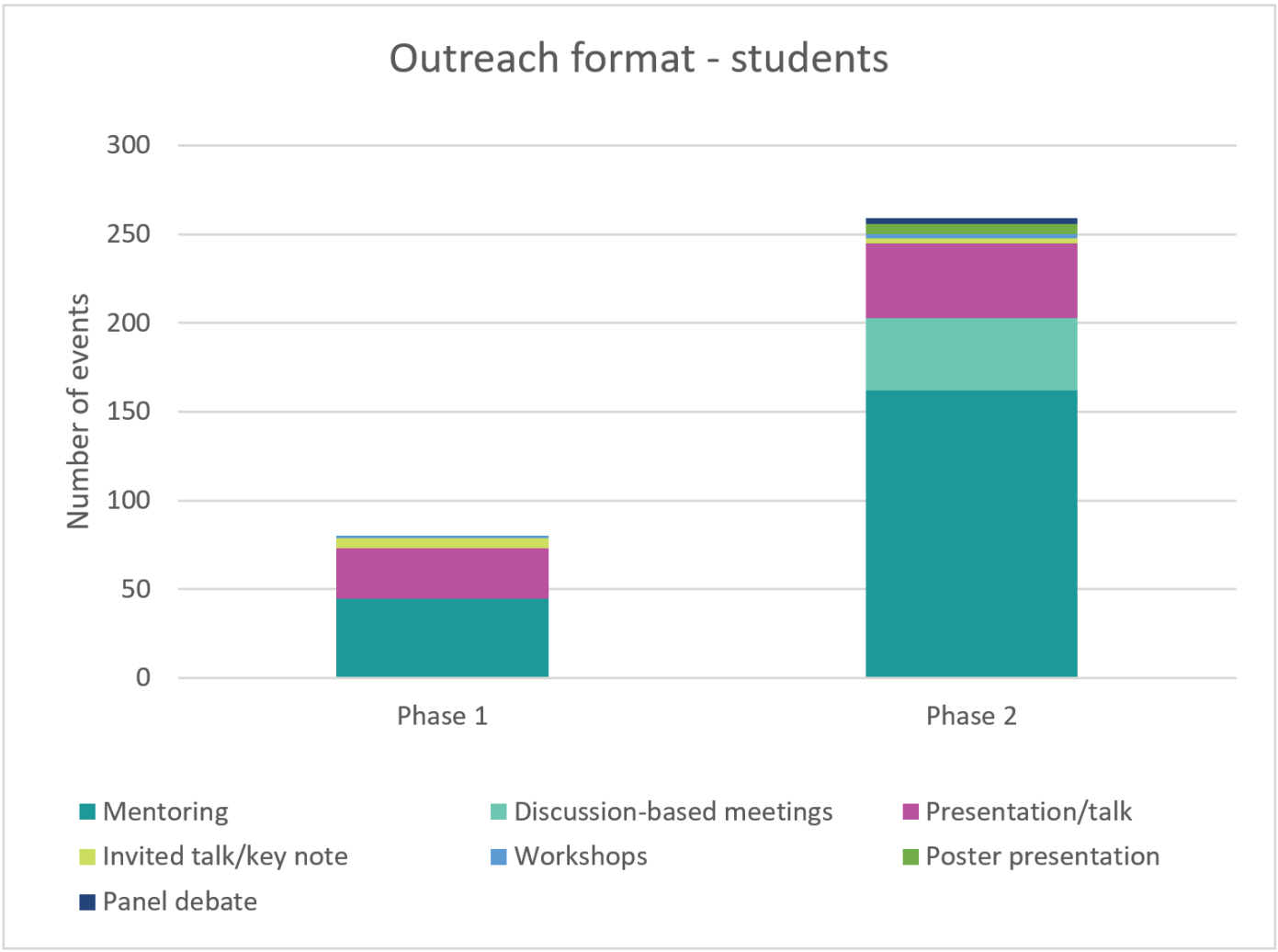


Figure 3.8. *The student contribution (n=343) in terms of outreach format divided into phase one (2014-2018) and phase two (2019-2023).*

Conclusion

In summary, bioCEED has learned that to facilitate true student partnerships we must:

- ensure that activities are meaningful for all involved.
- ensure that student effort and contribution are acknowledged, valued, and rewarded.
- trust the students and ensure autonomy and agency for student partners.
- allow for varying degrees of involvement with respect to responsibility, effort, and outcomes for all involved.

Clearly, involving students as authentic partners has increased the quality and relevance of our work. However, we worry about sustainability of these partnerships. Without funding, we are asking students to volunteer their time, leading to opportunities that will be most available to those with the most privilege. Further, in an ideal future scenario, institutions would see promoting these relationships as a core part of their educational mission. The students that have worked with us have had unparalleled educational experiences, and they have contributed meaningfully to the education of their current and future peers. We have benefitted from the student perspective, energy, and enthusiasm. We hope some version of this initiative will continue beyond bioCEED.

List of hyperlinks used in this chapter

20. biORAKEL: https://biorakel.w.uib.no/
21. UNISbreakfast: https://unisbreakfast.w.uib.no/
22. biORAKEL: https://bioceed.w.uib.no/resources/toolkits/toolkit-bioracle/
23. UiB Learning Environment Price: https://www.uib.no/nt/120014/biorakel-fekk-l%C3%A6ring-smilj%C3%B8prisen
24. Kvalitetstid: https://shows.acast.com/kvalitetstid/episodes/hvordan-far-man-til-studentpartnerskap-i-utdanning
25. NOKUT podcast nr 60: https://soundcloud.com/nokutpodden/den-om-studenter-som-partnere-for-og-na
26. bioHIVE: https://bioceed.w.uib.no/resources/toolkits/toolkit-biohive/
27. Gya & Bjordal 2017: https://bioceed.uib.no/dropfolder/bioCEED/MNT2017-Gya.pdf
28. opening keynote: https://issotl18.w.uib.no/keynote/conference-opening/
29. Challenges and Benefits in Involving Students as Partners to Improve Teaching and Learning Culture (Bjordal and Lygre 2018): https://issotl18.w.uib.no/thursday/thursday-psa/#psa
30. student poster symposium: https://bioceed.uib.no/dropfolder/bioCEED/Poster-ISSOTL23-Posters.pdf
31. BIO299: https://bioceed.w.uib.no/resources/toolkits/toolkit-bio299/
32. Teach2Learn: https://teach2learn.w.uib.no/
33. SCOPE: https://scope-conference.weebly.com/
34. Bikuben: https://bikuben.w.uib.no/en/
35. bioSPIRE and UNiSprout: https://bioceed.w.uib.no/resources/toolkits/toolkit-biospire-unisprout/
36. pedagogical escape rooms: https://bioceed.w.uib.no/resources/toolkits/toolkit-gamification/
37. student resources and offers: https://bioceed.w.uib.no/resources/explore-bioceed/
38. ReDesign project: https://bioceed.w.uib.no/redesign/
39. Development, testing and evaluation of tools and assessment forms that promote course alignment in field and lab teaching (FieldPass project): https://bioceed.w.uib.no/fieldpass/
40. student active learning spaces at UNIS: https://www.unis.no/news/new-learning-spaces/
41. Learning Arctic Biology platform: https://www.learningarcticbiology.info/
42. instructional videos: https://bioceed.w.uib.no/videos/

4. Innovative Teaching

Sehoya Cotner, Kristin Holtermann, Lucas Jeno, Jonathan Soulé & Oddfrid Førland
with valuable contributions from the core team

Introduction and background

A third bioCEED focus area has been *Innovative Teaching*, which we can generally define as any attempt to improve learning by implementing evidence-based pedagogies informed by an understanding of cognition and motivation. We initially envisioned Innovative Teaching as involving two strategies: optimal learning environments (aligned with WP 2 Learning Environments) and active and motivated students (WP 3 Active Students) (UiB, 2013).

To achieve optimal learning environments, we sought to:

- Align curricula, skills training, practice opportunities, and evaluation with learning goals.
- Optimize the physical and digital learning environment to foster learning across the biological 'domain' (content knowledge, skills, and societal relevance).
- Pursue continuous optimisation of technical and administrative support to educational needs.
- Engage staff and students in renewal of the broader learning environment.
- Define the 'domain of biology' by the interactions between the development of scientific content knowledge (theory, factual knowledge) and practices within biology itself, and society's applications of and needs for this knowledge and these skills.

And to support active and motivated students, our strategic aims were to:

- Set learning goals that engage students actively in pursuit of competence across the biological 'domain' (content knowledge, skills, and societal relevance)
- Integrate problem-solving and learning-to-learn skills in the curriculum.
- Increase hands-on experiences with research, industries, management and education.
- Provide students with formative feedback.

Below, we elaborate on how bioCEED achieved these aims. As for "engaging staff and students in renewal of the broader learning environment," we refer the reader to the previous chapters on *Learning Culture* and *Students as Partners*. We do not attempt to cover every activity or accomplishment, but rather highlight select initiatives and outcomes to paint a picture of the centre's impact over time.

Core achievements in Innovative Teaching

bioCEED has collaborated with staff and students to align our curricula, skills training, practice opportunities, and evaluation with learning goals.

Much of the curriculum alignment was accomplished through smaller projects and several offerings of the Collegial Teaching and Learning in biology/STEM (MNPED660)[43] course. Further, in several Teachers' Retreats, Learning Forums, workshops, and Digital Teachers' Meetings we sought to bring

students, teachers, and administrative staff together to map, develop, and assess teaching and learning.

In collaboration with the externally funded ReDesign project[44] (a 4-year collaboration project with BIO, the UiB Learning Lab, and bioCEED), we emphasized dialogue around constructive alignment in the BIO curriculum. The ReDesign project piloted and adapted the Program (re)design model for Learning Centered Curriculum (Fowler et al., 2015) to the Norwegian higher education context, and UiB in particular, through the redesign of the BSc biology. Based on this experience, the Learning Lab developed a UiB framework for study program development and redesign (see "Utvikling av studieprogram[45]").

The frameworks constructive alignment and the SOLO taxonomy (Structure of Observed Learning Outcomes) guided the process of programme redesign, matching clear learning objectives with updated learning outcome descriptions, student-centred learning activities and evidence-based assessment. The ReDesign project outcome is testable learning objectives with active learning verbs and increased skills training.

But as much as the *outcomes* matter, the *process* we facilitated may have made the most lasting impression. Student partnership was integrated in the project throughout the four years of activity, as in the student-led workshop (Fig. 4.1), where students were asked to give input on the curriculum, and the students simply took over. The messages they shared that day permeated the remaining three years of the project (Førland & Holtermann, 2023).

> *"I think being part of the ReDesign team was very interesting and meaningful. I think it is very important that we have students involved in such a process. Also, I was part of the ReDesign project as a student during the first early workshop. And then later I hosted a workshop where we discussed the program learning outcomes (PLOs). It was very nice being involved in that process. I was involved in the mapping of general competencies and skills in the different courses, with focus groups that involved other students...before that, me and Sondre did a little "pilot" of this project. That is where we found out there were a lot of things lacking in the course descriptions. So then we started the formal mapping with Christian and the ReDesign team."*
>
> Testimonial from Pernille Eyde Nerlie (2024), student partner.

In addition to student involvement, teacher and staff feedback on the programme redesign was solicited, and integrated, in a series of workshops and annual teachers' meetings (Fig, 4.2).

Figure 4.1. *Students giving input on the BIO curriculum at a student-led workshop in 2021.*

The ReDesign project involved a close look at whether course activities and assessments matched the intended learning outcomes (ILOs), through the perspective of the educators and the students. The evaluation method CALEQ[46] was tested for Norwegian higher education. Several courses across the faculty have integrated CALEQ into their course surveys, and it has been shared in several presentations and a manuscript (Strømme et al.) is in review.

Figure 4.2. *Staff members from across BIO group cross-curriculum ILOs at the Teachers' Retreat in Voss, June 2022.*

We have worked to optimize the physical and digital learning environment to foster learning across our three-pronged biological 'domain'.

Many bioCEED efforts have focused on improving the physical and digital environment to support student learning, and we present some examples in this section.

bioCEED staff, in collaboration with the student council, played a key role in developing new student-active learning spaces at UNIS. These areas were designed for both individual and collaborative work outside the teaching hours. They are important and necessary contribution to improve the student`s learning environment, generic skills development and student-active research opportunities at UNIS. Student surveys showed that most students use the learning space several times a week and view them essential or highly important to the learning environment at UNIS.

Fieldwork on Svalbard can be challenging and resource-demanding. To optimize the use of nearby field areas around Longyearbyen and improve teaching and research, a local field laboratory was established with external funding (Olav Thon Foundation). As part of the Bjørndalen Integrated Gradients (BIG) project, the lab offers a well-equipped research platform. This facility enables students to engage in ongoing research projects through internships and courses, providing them with valuable, hands-on research experiences. It also serves as a site for certification. Additionally, Virtual Field Guides (VFGs) allow students and faculty to explore the site remotely, whether for preparation, follow-up, or during times when access to the area is limited.

Several small and multi-year projects had *improving the learning environment* as their primary aim, including initiatives to improve the laboratory and field experiences. Examples include a bioCEED mini-grant to support the development of a pedagogical escape room[47], the long-lasting development and research on the ArtsApp[48], learning by making videos in Teach2Learn[49] and the extensive field teaching development and research with the FieldPass[50] project.

bioSKILLS[51] is a platform of online tools that serve students as they develop key transferable skills such as digital and numerical competency, scientific communication, and academic writing. In 2014, bioCEED initiated bioSKILLS to provide both biology teachers and students with digital resources designed to facilitate learning of transferable skills. The motivation for bioSKILLS originated from conversations with 1) biology teachers' observation that students lacked the basics of numerical competency and writing skills and 2) stakeholders (i.e., work placement mentors) reporting a general lack of key competencies among the biology students they host.

To develop these digitals resources, the bioSKILLS core team created two task forces bioST@TS[52],

a web platform dedicated to tackling student challenges with numerical competency, data management and statistics, and bioWRITE[53] (English platform) and bioSKRIV[54] (Norwegian platform), platforms dedicated to academic writing and scientific communication.

The bioST@TS task force gathered biology teachers, researchers, postdoctoral researchers and bioCEED core team members who identified and discussed the topics, methods, and content to be designed. In 2016, bioCEED released the first version of bioST@TS[52], introducing students to the basics of data collection and management, statistical analysis, data transformation and visualization. The content is organized as tutorials and examples, with interactive parts, and is based on the programming language R and the user interface RStudio. Directed towards both BSc- and MSc students, bioST@TS provided resources that are relevant primarily, but not exclusively, for biology courses at UiB and at UNIS. The platform made broad use of videos since this media has been found to increase student achievement, competence, learner satisfaction and engagement (Carmichael et al., 2018). bioST@TS learning modules for BSc students focused on the basics of data management and visualization through tables and charts in MS Excel 2016. Modules for MSc students included statistical analysis and applied the open-source programme R, with instructions to the coding needed in this program. bioST@TS also offered videos that explain key concepts in statistics using simple, concrete examples in biology, and is a repository for resources created in collaboration with both teachers and students.

bioST@TS has been successful in several ways. First, it provides students with simple and short tutorials and guidelines that are aligned with the needs of our programmes in biology, and thus constitutes an efficient tool to assist them in their daily numerical tasks. Second, bioST@TS offers a toolkit for biology teachers to develop numerical/coding exercises adapted to their own biology courses. The webpage contains a set of standardized building bricks that biology teachers use as a resource for the students in practical activities, where they are expected to handle and analyze data and produce scientific reports including illustrations, tables and figures.

During the past four years, the website has undergone important changes that reflect how programming and statistics are currently taught at BIO. The changes have made bioST@TS a platform that now serves even more as an integrated teaching resource for the major introductory course in biological statistics in the MSc programme in Biology at UiB, while still providing content adapted to other programmes and interests. The platform is better aligned with our teaching and represents something akin to a digital handbook for biological statistics and data management.

Similar to bioST@TS, the bioWRITE task force gathered biology teachers, researchers, postdocs, PhD students and bioCEED core team members to identify and discuss the topics, methods, and content to be designed. In 2018, the task force conducted a thorough mapping of academic writing in the core biology courses of the BSc programme (curriculum mapping) and formulated specific learning goals for different competences in writing and communication. The workgroup identified the challenges that biology students encounter in their curriculum and needs for further support in academic writing and started developing web-based resources for the platforms bioWRITE[53] (contents in English) and bioSKRIV[54] (contents in Norwegian) to come.

In 2019, the platform bioWRITE/bioSKRIV went live, presenting both general and course specific resources. As the IMRaD format is the well-known and broadly adopted overall structure for articles published in journals relevant for biology in its many subdisciplines, a central part of the platform was designed to describing the format and its sections, identifying their function and structure, providing examples and tips, etc. Another important section of the platforms served to identify the genres of science communication i.e. lab journal, report, essay, etc. and explain their specific purpose

and structure, again providing concrete examples and tips.

The work was coordinated with the teacher group "BIO100 club" (Box 2.3) to ensure that the resources produced for different levels would be both useful for and aligned with the biology courses and programmes, and can be supplemented with course-specific examples, illustrations and tasks. bioWRITE has been implemented in several introductory courses at BIO, and it has become a central resource for skills-training and as an assessment reference that sets the standards for student written work.

Practical teaching and learning such as labwork, fieldwork and research cruises, are an integral part of our educational programmes. They are known to underpin student engagement and learning experience by a variety of means. Course-embedded practical activities improve content-knowledge acquisition, and increase practical, academical and professional, and collaborative skills. These activities are important factors with regard to developing student motivation, sense of belonging and academic community (Hole, 2019). Not surprisingly, conducting practical biology is regarded as one the most important skills to prepare postgraduates for work in the environmental sector.

Although beneficial to the learning experience of biology students, practical learning activities are costly. Course leaders often find themselves in situations where on-site efficiency and contribution must be kept at a high level to reach the objectives within the given resources and time. For the students, practical activities are also demanding as they require a larger investment in terms of study time (preparation) and often a physical contribution, especially considering fieldwork in remote places. The preparation phase to fieldwork and lab work should be thus regarded as determining for increasing course efficiency. Preparation ought to constitute a central component of practical courses in which students are taught to review the objectives of the activities, the employed methodology, the logistic and practical constraints, the environmental factors impacting safety, etc. All these resources, if existing, are often available in the form of books, compendia etc, which is often unpractical *in situ*.

In the past years, bioCEED has dedicated a significant amount of resources in developing innovative platforms that support preparation to practical courses. Two of these resources are 1) video tutorials, i.e. short instructional videos and 2) Virtual Field Guides (VFGs).

Learning activities in the biology lab often consist of exercises based on sequential execution of a protocol or a procedure that is time consuming, and requires costly instruments, reagents, and/or consumables. It is important that students are made familiar with the purpose and the practical aspects of the activities ahead of time. Our teachers have often reported low levels of preparation among students that impair to various extent the efficiency of the practicals. To support students in preparing for lab work, bioCEED has assisted course teachers in designing and producing video tutorials that visually introduce students to the activities, their purpose and contents, their sequential development. These short videos, made to all available at https://bioceed.w.uib.no/videos/ and through our learning management systems, have become permanent elements of the course material.

In parallel, Teach2Learn[49], a project initiated by bioCEED in the period 2015-2018, offered students enrolled in specific courses at BIO and UNIS to contribute to the pool of tutorials by making their own, taking elements of the practical activities as subject for the short films. Teachers of these courses would be able to 1) assess student learning through direct evaluation of the quality and contents of the video tutorials and 2) reuse the newly created tutorials as teaching material during the subsequent semesters, providing that they were found of satisfactory quality. In parallel, students making videos would engage in the task in a creative manner to produce materials that convey the background and goals of the activities, while developing better understanding of the topic, ownership

of learning, as well as a sense of accountability, critical thinking and confidence. As for peer students watching these videos, they would have access to a library of materials matching their academical level, their communication style, thus making concepts more graspable and less intimidating. Benefits would include improved retention, relatability, enhanced engagement and motivation in the learning process.

The project FieldPass[50] at UNIS has also created video tutorials, covering the high variety of research instruments and field methods that are employed at teaching resources both in biology and astrophysics courses. For instance, some of these videos deal with safe and proper use of bench microscopes. FieldPass has incorporated these videos in a certification programme where students learn through the videos, train on the instruments and get evaluated on performance of their newly-acquired skills by teaching staff or peer students who have themselves already undergone the certification[55] process.

The videos produced by bioCEED have contributed to expand the quality and relevance of our course materials dedicated to practical teaching. They have successfully contributed to increasing the level of preparation for students engaged in practical activities.

VFGs[56] are Google Street View-like platforms that take students on a virtual tour in the Svalbard archipelago and introduce biology students at UNIS to 18 fieldwork locations (as of March 2024), their topography, biological diversity, abiotic features, and much more. Constituted of 360 degree-pictures stitched together in a panoramic tour, VFGs are the ideal tool to prepare students for upcoming on-site activities, to better understand the challenges imposed by the terrain and climate, the safety issues one may encounter, and the variations in flora and fauna that make studying on Svalbard transformative for future biologists. For specific locations, the platform also provides access to seasonal VFGs, which display the changes in landscape and vegetation month-by-month throughout the seasons (Eidesen & Hjelle, 2024).

Initiated in 2019 as part of FieldPass, VFGs and the complementary web-platform Learning Arctic Biology[57] are fully integrated components of the teaching and learning materials that UNIS actively uses and continues to develop. BIO has started developing similar VFGs for a handful of locations around Bergen, which are also connected to specific biology courses.

bioCEED has pursued continuous optimisation of technical and administrative support to meet evolving educational needs.

Much of this optimisation activity concerns revising and maintaining the resources discussed above. However, we highlight one example of how technical, administrative, and teaching staff have worked together to refine and maintain two related bioCEED projects—bioPITCH[58] and the Student Poster Symposium at BIO.

Figure 4.3. *Student Poster Symposium, BIO.*

Scientific posters constitute a standard way to communicate scientific results. Posters can also be a pedagogical tool that help students learn the course content, while practicing dissemination as a skill (Marino et al., 2000). At BIO, several biology courses now include science communication and dissemination as part of the ILOs, and participate in the Student Poster Symposium as part of the

course learning and assessment. In line with constructive alignment (Biggs & Tangs, 2011), courses have added poster assignments to their curriculum, and redefined course assessment to include poster presentation (Soulé et al., 2023[59]) (Fig. 4.3).

Table 4.1. Overview of poster presentations, student presenters and participating courses per semester.

Semester	format	posters	students	BIO201	BIO219	BIO241	BIO250	BIO299	BIO300A	MOL231	MOL270	SDG214	SDG215	GEOF338
Spring 2019	on campus	18	59	X		X		X				X	X	
Fall 2019	on campus	17	26				X	X						
Spring 2020	digital	26	113			X		X				X	X	
Fall 2020	digital	20	51				X	X	X					
Spring 2021	digital	45	133			X		X		X		X	X	
Fall 2021	on campus	31	104	X			X	X	X					
Spring 2022	on campus	37	116			X		X		X		X	X	X
Fall 2022	on campus	52	157	X			X	X	X	X	X			
Spring 2023	on campus	46	123		X	X		X		X	X		X	X
Fall 2023	on campus	54	155	X			X	X	X	X				
Total		**346**	**1037**											

Starting in 2019, bioCEED and course teachers have hosted a biannual student poster symposium at BIO[60]. Courses that include poster presentation as assessment are invited to contribute to the symposium. As of 2023, a total of 11 courses (Tab. 4.1), 346 posters, and over 1000 students have been involved, in addition to the engagement of session participants. All posters are displayed in a large and open arena, allowing student presenters, teachers, and visitors to mingle and discuss topics as varied as ecology, paleoecology, Sustainability Development Goals, molecular biology, biodiversity, bioethics, and more. Participants can give feedback to the poster authors via a digital forum (bioPITCH58, see below) and thus contribute to student learning by sharing their impressions and perception of the presented work.

Students' posters are also displayed online via the bioPITCH[58] platform (Fig 4.4), where students can find inspiration and students' work is disseminated to a larger audience. Posters are given a unique QR code and link, which students can use to document their work, for example to potential employers and link to their personal CV This way, the poster is a form of assessment that outlives the course.

With the Student Poster Symposium at BIO, bioCEED has created a forum for students and teachers to discuss biology in its many subdisciplines. The symposium enables students to show their skills, understand the ways biologists communicate to their peers, and share their opinions and have their voices heard. Students have a chance to show their product both on site at the symposium and in their résumés via links to bioPITCH[58].

While many examples of how we have collaborated to renew the broader learning environment are discussed in the Learning Culture chapter, we will here point to a few key examples

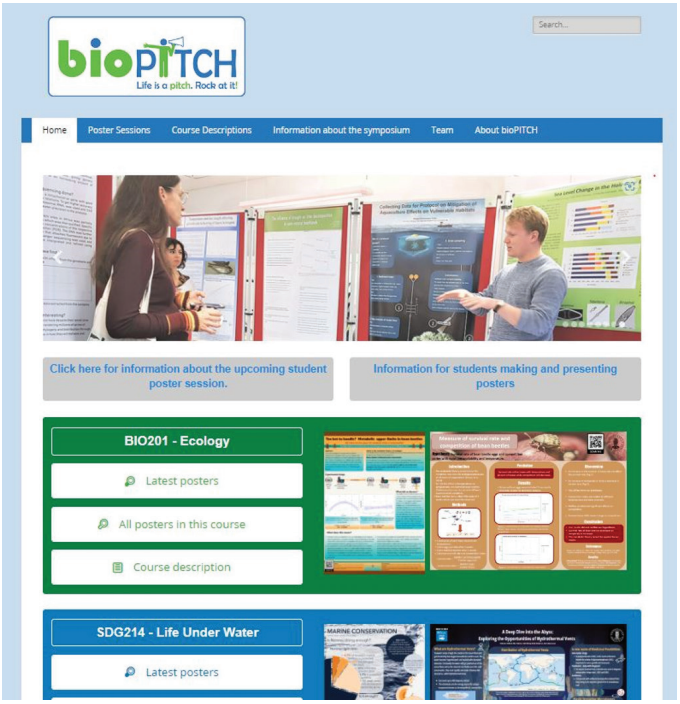


Figure 4.4. The bioPITCH platform. bioCEED has engaged staff and students in renewal of the broader learning environment.

of how students and staff have collaborated to improve course learning environments. We specifically highlight our work with student and instructor motivation, authentic learning experiences during field, lab, and work-practice courses, the impacts of active learning on student affect and performance, and our collaborative efforts to better understand the classroom microclimate and its impacts on student affect and participation.

Student and Instructor Motivation

ArtsApp[48] is a digital tool for species identification developed to enhance motivation in biology students. ArtsApp was tested during field courses to investigate its effectiveness compared to a traditional textbook alternative. We found that students using the ArtsApp scored higher on motivation and on an achievement test, relative to the textbook. Several of these studies have shown that the inbuilt features of ArtsApp were directly linked to increases in motivation, which in turn was related to higher scores on achievement tests (Jeno et al., 2017, 2018, 2019, 2020, 2022). Using Self-Determination Theory, Lucas Jeno and colleagues have been able to pinpoint the factors that contribute to our understanding of how using different educational technologies improves student engagement and their perceived learning (Jeno et al., 2021; Alamer et al., 2022).

We have also explored how teachers impact students' motivation and achievement, and the relationship between students' motivation and performance in general. Some studies have looked at how more intrinsic motivation among biology students has been negatively related to dropout, and positively linked to students' grades and self-reported learning (Jeno et al., 2018, 2021). We have also seen that teacher behaviors such as providing students meaningful rationales for doing a learning task, or giving students optimal challenges, increases their intrinsic motivation (Johansen et al., 2024; Yasué et al., 2019). In a similar vein, we have documented demotivating factors such as test anxiety and a strong focus on extrinsic life goals (Cotner et al., 2020; Johansen et al., 2023a, 2023b).

Authentic learning experiences during field, lab, and work-practice courses

Much of our experience with embedding authenticity into the curriculum (e.g., via the work and research practice courses at AB and BIO, as well as through the FieldPass project and the PFTC courses) is discussed elsewhere. In summary, bioCEED collaborations have advanced our understanding of how students perceive educational value in field courses (Hole, 2018; Hole et al., 2022), how open data sets can supplement and support field and lab courses (Geange et al., 2021; Strømme et al., 2022), novel ways to engage students in culturally relevant activities (Patrick et al., 2018, 2020), best practices for supporting work-practice supervisors to improve the student experience (Schneider et al., 2024), and creative models for open inquiry in introductory biology courses (Gya & Bjune, 2021).

Here we highlight Torstein Hole's work on student perceptions of field courses, which focused on how students learn through different forms of practice in biology education. Hole's PhD research examined student learning in field courses and work-practice courses. Specifically, Hole's analysis explored how experiences in practical settings relate to the development of students' personal epistemology, their understanding of the subjects they study, their approach to learning, and their role as future biologists (Hole, 2018; Hole et al., 2022). Additionally, his research highlighted various pedagogical opportunities in field course instruction, including student assessment through blog posts (Velle et al., 2017; Hole et al., 2018).

The impacts of active learning on student affect and performance

bioCEED has long been concerned with facilitating active learning in teaching practices. In an early theoretical paper, Jeno discussed how active learning can be investigated through the lens of Self-

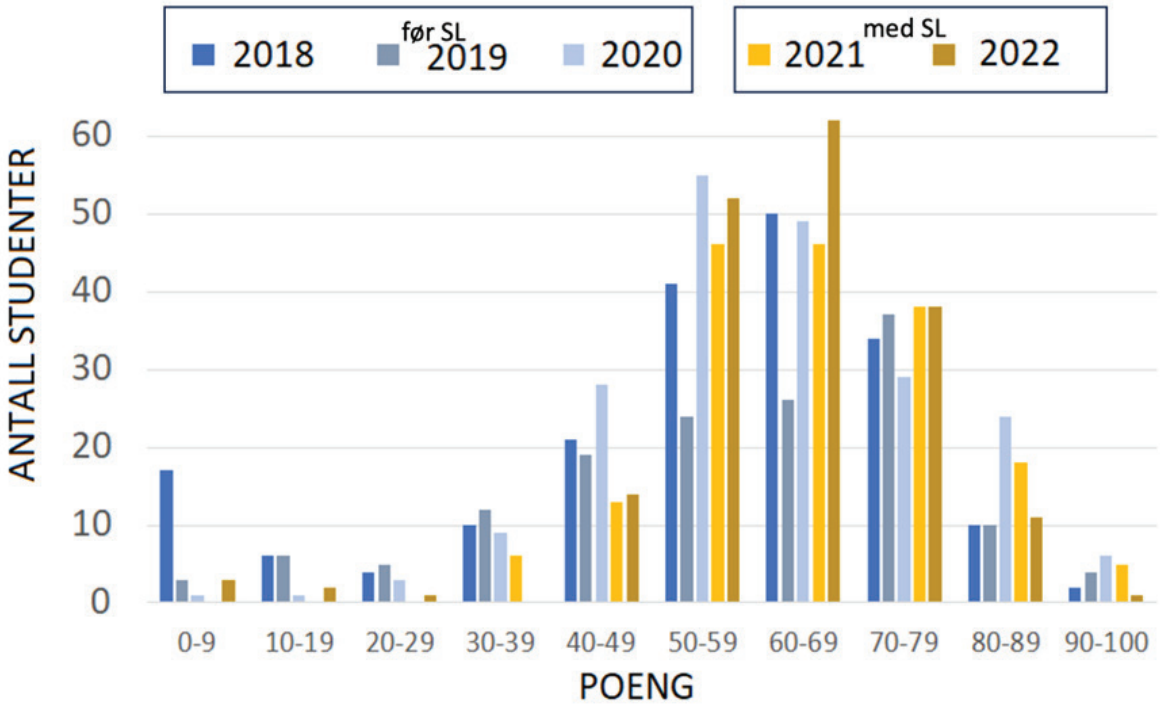


Figure 4.5. *In BIO100, the transition to TBL led to a noticeable reduction in failure rate and an increase in course completion. Points (0-100) over 3 years with (2018- 2020, før SL), and 2 years with (2021-2022 med SL), TBL (label SL). Data includes all students enrolled at the semester start in August.*

Determination Theory (Jeno, 2015). A follow-up study was an empirical investigation, which tested the effect of implementing TBL on motivation, engagement, and learning. The results showed that implementing TBL enhanced students´ motivation, engagement, and learning (Jeno et al., 2017). Recently, instructors revised the first-semester introductory-biology course BIO100 to be organized around a TBL framework (Michaelson et al., 2004). They implemented the prototypical TBL pedagogy—pre-class preparation, individual readiness test, group readiness test, appeal opportunities, and class activity—and saw dramatic results (Fig. 4.5). Specifically, more students complete the course now, failure rates have gone down, and students really value TBL (Kawousi & Barry, 2023[61]).

Convinced by these outcomes, several of our colleagues in biological sciences, geosciences, chemistry, and mathematics are now teaching with TBL and realizing similar results to those of the BIO100 instructors. Collectively in The Faculty of Mathematics and Natural Sciences (MN Faculty) at UiB, over a thousand students each year are learning in introductory-level courses that are using this evidence-based pedagogy.

As part of Anja Møgelvang's PhD work, the second-year course BIO103 introduced Cooperative Learning (CL). In this course, students received lecture instruction, followed by CL, followed by lecture again. Møgelvang's analysis demonstrated that students engaged in CL had higher self-efficacy, higher sense of belonging, a greater sense of transferable-skills acquisition, and a reduction in loneliness, relative to the same students experiencing traditional lecturing (Fig. 4.6, Møgelvang et al., 2023). CL continues in BIO103, and because of these findings, CL will be implemented in a large-enrolment, introductory chemistry course in Fall 2024. Further, Møgelvang has been invited to share CL, and her findings, with instructors across UiB and UNIS.

"Inspired by the digital work done by Anne Bjune and Jonathan Soulé at bioCEED, some of our projects were developed and funded. This allowed us to bring Jonathan into the

department to assist with developing our digital platforms for our laboratory courses. In our ongoing process on developing the chemistry lab as a learning arena, we were also inspired by bioCEED and Anja Møgelvang to use CL in pre- and post-laboratory work in groups in our now-active CoChem project. bioCEED has also encouraged us to become involved in educational research activities and we have a PhD student to start soon working on a CL theme with Anja and Sehoya as co-supervisors."

Monica Jordheim, Chemistry professor, UiB

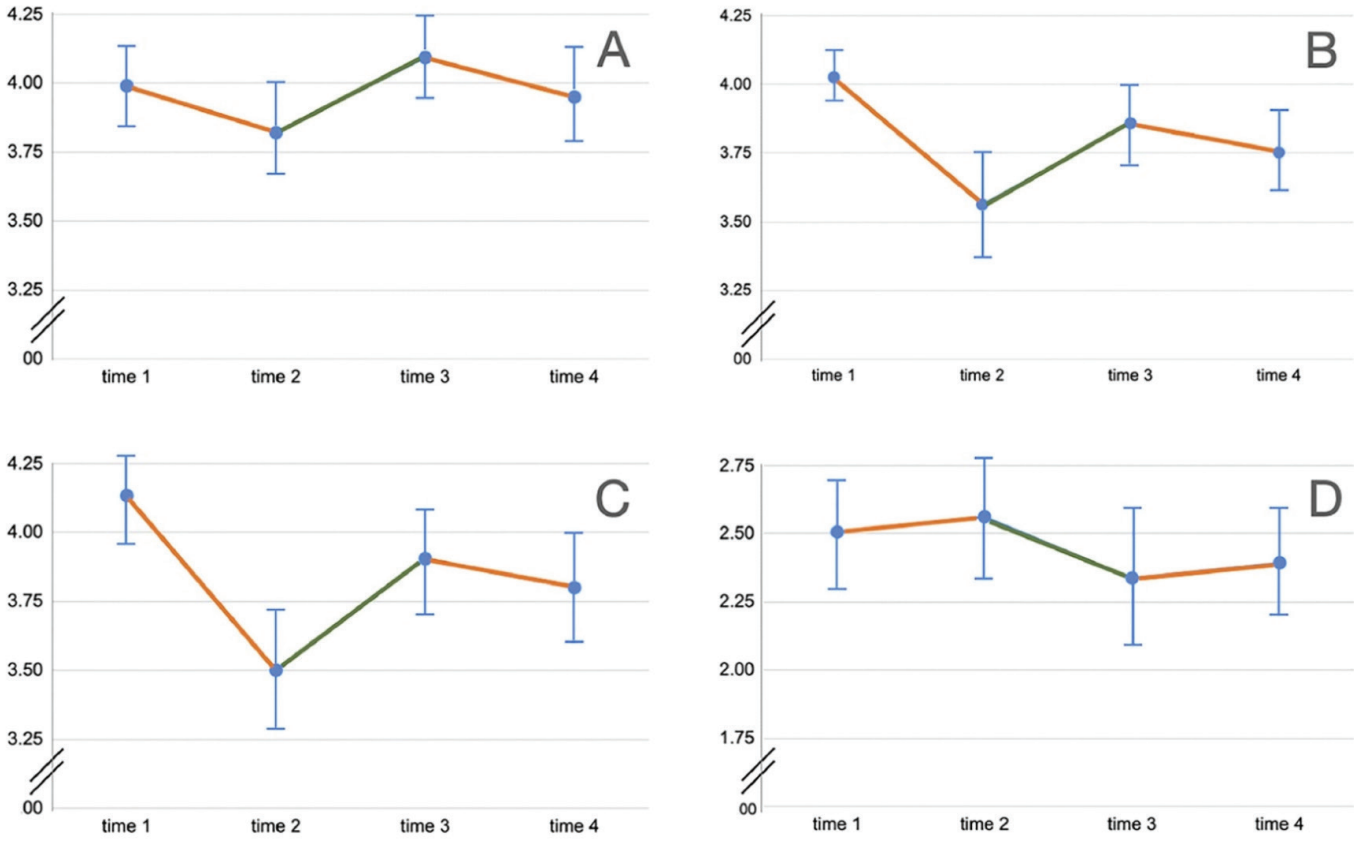


Figure 4.6. *In BIO103, the switch from traditional lecturing (time 1) to CL (time 2) was associated with changes in student A. sense of belonging, B. perceptions of generic skills acquisition, C. loneliness, and D. confidence. Data from Møgelvang et al., 2023.*

The classroom microclimate and its impacts on student affect and participation

Another way bioCEED research has impacted teaching and learning is through our investigations of the classroom microclimate. In 2017, Cissy Ballen and Sehoya Cotner began a series of studies on participation in different classroom environments—field, lab, and traditional lecture. Initial work established that women were under-participating, relative to their male peers (Ballen et al., 2017). These findings led to a large-scale study of over 40 biology courses, across three countries and involving several UiB courses (Ballen et al., 2019). We concluded that smaller classes, and instructors that used a diversity of strategies to elicit input from students, were associated with gender-equitable participation. These findings have been shared across Norway, and the researchers have been asked to give several workshops on how to encourage equitable student participation in our courses.

"With the support of bioCEED and its affiliated faculty, we pioneered some of the first research documenting disparities based on gender in higher education spaces in Norway,

demonstrating the need to advocate for equitable teaching strategies, even in Norway which is known for its political and social gender equality. This work changed my thinking about STEM equity as an 'American problem' to one that poses challenges to institutions globally."

Cissy Ballen, Associate Professor, Auburn University (USA)

More recent work, conducted in collaboration with iEarth—through bioCEED mini-grants and iEarth seed funding—has focused on student sense of belonging across several introductory-level MN Faculty courses. Surveys in these courses revealed that women and first-generation university students (those whose parents did not attend higher education) professed a lower sense of belonging than their male, continuing-generation peers. Further investigation revealed a significant inverse relationship between sense of belonging and test anxiety, leading us to conclude that test-anxiety interventions might be helpful in improving the classroom experience for all students—and especially women and first-generation students (Costello et al., in review).

Recently, a cross-MN Faculty investigation, supported by bioCEED and in collaboration with the SFU MatRIC at UiA (University of Agder), explored the impact of three different test-anxiety interventions on student performance and test anxiety. We studied outcomes from TBL in math and biology, an experimental cognitive-reappraisal intervention, and the transition from high-stakes to low-stakes testing in an introductory-mathematics course. We found that of those three, only low-stakes testing was associated with improved performance and a significant reduction in test anxiety (Tab. 4.2, Thormodsæter et al., in preparation). These findings have led to a focus on evidence-based assessment.

Table 4.2. *In a comparison of three different interventions, involving several introductory-STEM courses at UiB and the UiA in Norway, only the shift from high- to low-stakes testing was associated with improved performance. Data from Ruben Thormodsæter, unpublished work.*

Fixed effect of different interventions:	**Estimate**	**Std. error**	**Pr(>|t|)**
Low stakes Testing: Yes	0.65	0.23	0.005*
Team Based Learning: Yes	-0,005	0.19	0.97
Reappraisal: Yes	0.14	0.14	0.29

Define the 'domain of biology' by the interactions between the development of scientific content knowledge (theory, factual knowledge) and practices within biology itself, and society's applications of and needs for this knowledge and these skills.

Many bioCEED projects have focused on interactions between the corners of the bioCEED triangle (Fig. 1.1): content, practice, and societal applications. For example, students engaged in the work practice courses (discussed in the chapter on Practical Training) apply content knowledge and practical skills to work during placements, thus learning more about different stakeholders in the realm of biology beyond academia. Another project that also began as a BIO/bioCEED collaboration, and which is now embedded in the curriculum, involves the introductory UiB biology course Organismal biology 2 – BIO102. In BIO102, instructors have both student-driven course-based research projects and the locally relevant "carbon project." In collaboration with students, bioCEED, course teachers, and the Heathland Centre at Lygra, we developed a system that allows students to engage in open inquiry within the context of several different ongoing ecology projects.

"I still use some lectures but am incorporating the plant identification app, ArtsApp, in novel ways with my assessment and teaching. My course also has developed a portfolio form of assessment where students develop a mini-masters-type thesis. I have also brought in a "fact

check" course assignment where students are required to fact check internet statements via the scientific literature. Another new assignment is where students write their own exam questions. Students are required to write 12 multiple-choice questions. A number of these student-generated questions are selected to appear in the course examination.

All of these were inspired by bioCEED or discussions around bioCEED and most would not have happened without bioCEED."

John Arvid Grytnes, Professor and BIO102 instructor

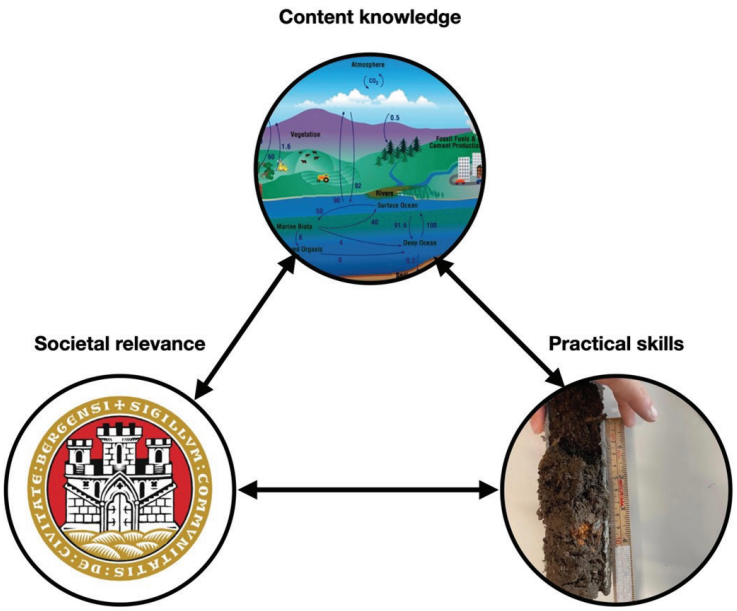


Figure 4.7. *The BIO102 carbon project in light of the bioCEED triangle, incorporating student knowledge (the carbon cycle), skills (measuring carbon storage via soil cores), and societal relevance (sharing these findings with Bergen Municipality. (Photo top: Atmospheric Infrared Sounder[63], licensed under the Creative Commons Attribution 2.0 Generic license[64]. Photo bottom right: Linnea Haneberg Wilmot).*

The carbon project involves a novel collaboration between BIO and the Norwegian Climate and Pollution Agency (Fig. 4.7). Students collect data from approximately 60 randomly selected points throughout Bergen municipality. In groups of two, collect and treat soil samples to estimate the carbon content. Student findings have surprised local stakeholders and staff at the Climate Agency. Essentially, students have found that flora and soil in Bergen stores, on average, more carbon than nature in the rest of the country (Barry et al., 2022). Both BIO and the Climate Agency have indicated plans to continue this collaboration, and the students value working with a project in which the "answers" are not known ahead of time. As student Hanne Tomasgård Olstad noted, "...we were able to take part in the entire process, from collecting samples, sifting and preparing these for drying and burning" (source BIO[62]).

Both the knowledge (of the carbon cycle) and the skills (measuring carbon storage) are competences that are used in municipalities in Norway. Municipalities need good knowledge of nature to manage it properly. For example, the Climate Agency used the students' findings when they gave input in a case where developers want to develop areas with natural bogs. Development of bogs is an unsustainable practice from a climate perspective, and the work of the students underscores this in a locally relevant, convincing manner.

Set learning goals that engage students actively in pursuit of competence across the biological 'domain' (content knowledge, skills, and societal relevance).

bioCEED has supported creative consideration of what should be possible after receiving a degree in BIO. In these activities, student involvement has been critical. Here, we highlight the student journal Bikuben[65], a scientific journal by and for students at BIO. Students have been involved at all levels—as authors, reviewers, art directors, and editors (Fig. 4.8). Two editions of Bikuben have been published, highlighting student work that ranges from evolutionary explanations for sexual reproduction (Michaelsen, 2021) to behavioural fear responses in songbirds (Kawousi et al., 2023). This project is so valued by the students that they recently proposed a new course to support the journal in the

absence of external funding. In their proposal, they note that "Bikuben is currently the only example of its kind where students have the opportunity to publish work that undergoes peer review and publication, where their fellow students are the target group. This will be work that ensures students an important and career-enhancing point on their CV that tells more than a report card. Learning about journals and publishing gives students hands-on experience with the process of scientific publishing. In addition, knowledge of publishing ethics, plagiarism and responsible research practices is increasingly important, ensuring that students are well prepared to maintain the highest ethical standards in their research and publishing activities. The latter is particularly important in light of the recent developments in artificial intelligence and the uncertainty this has created in an environment where work is to be its own."

Figure 4.8. *Student partners and editors of Bikuben Silje Høydal, Jørund Johansen and Lars Martin Myhre with the first edition.*

> *"I think what I am most proud of is Bikuben volume 2 (Fig. 4.9). The amount of work that went into it, promoting it, being approached by fellow students who wanted to contribute... becoming aware of a community that wanted to engage with Bikuben, and that I was in the centre of it was a positive experience. It was a lot a lot a lot of work, but it was, and still is, something I am super-proud of."*
>
> Hanif Kawousi, student, editor and author.

Integrate problem-solving and learning-to-learn skills in the curriculum.

Our efforts in this strategic aim are embedded in several of our activities, like bioCEED-supported initiatives with TBL, CL, FieldPass certification and video field guides, etc. Here we highlight a new example—gamification of learning objectives through escape rooms.

Figure 4.9. *Front page of the student journal Bikuben, volume 2.*

In 2021, student Ruben Thormodsæter received a bioCEED mini-grant to collaborate with Professor Anne Bjune and create an escape-room activity to learn about tools and research approaches in Bjune's BIO250 Paleoecology course. Specifically, students solved puzzles while learning about different techniques and basic concepts from the syllabus. For example, previous students had struggled to understand how tree rings can make a timeline stretching many generations. The escape room targeted this problem, creating a puzzle where students needed to place multiple tree rings together where they overlapped, to get the correct date (and open a lockbox!) (Fig. 4.10). This project was well received by the teachers and students, and it has since been used as an inspiration at UNIS. Also, several other instructors have contacted us to discuss details of escape-room development. Thormodsæter has given many presentations

and workshops about this activity, and has written a toolkit entry[66] about escape-room pedagogy.

> *"In the end, we had a physical escape room – both at UiB and at UNIS. Even though I didn't create the escape room at UNIS, I was part of that as well through us having a workshop at the Learning Forum there in 2022. The domino effect...that is what I see. I understand that better. Having these workshops helped to create something bigger."*
>
> Ruben Thormodsæter, student.

Figure 4.10. *Escape-room and escape-box supporting materials. Photo: Ruben S. Thormodsæter.*

Increase hands-on experiences with research, industries, management and education.

Through many different projects, bioCEED has supported students in gaining hands-on experience with research (e.g., bioSPIRE and UNISprout, the AB-207 Research Project in Arctic Biology, the BIO299 Research Practice in Biology, the PFTC international courses, the BIO102 Organismal Biology II research projects, the BIO poster session), industries (BIO 298 Workplace Practice in Biology, AB-208 Internship in Arctic Biology, the BIO102 carbon project), management (e.g., IMR, Norwegian Climate and Pollution Agency, NORCE, Bergen Municipality) and education (e.g., student partnerships leading to co-creation, biORAKEL, Bikuben, ArtsApp, Learning Arctic Biology Platform). For specifics on several of these projects, we refer the reader to the chapter on Practical Training and the bioCEED web pages.

Provide students with formative feedback

Core to our efforts has been an emphasis on evidence-based assessment. bioCEED have led several assessment-related initiatives, resulting in reformed assessment practices in courses BIO100 Introduction to Evolution and Ecology (formative assessment integral to TBL), BIO102 Organismal Biology II (portfolio assessment), BIO104 Comparative Physiology (oral exams), BIO298 Workplace Practice in Biology, BIO299 Research Practice in Biology and AB-208 Internship in Arctic Biology (blog posts), and the broad use of poster creation and presentation in many courses as part of the poster session described above. Further, many of our colleagues have integrated different types of "light touch" formative assessment (e.g., classroom-response applications such as PollEv, Kahoot, and Menti) in their courses. We also spoke out in several fora against the proposed "two-sensor" law in 2021, and we published on how instructors could envision fair assessment under that law (Harlap et al., 2022). Most recently, bioCEED lead colleagues across MN Faculty and UNIS in a "Large Language Models (LLM) in Education" learning community. This group engaged in three workshops, implemented novel assessments using new tools such as chatGPT in our courses, surveyed students, and instructors about these tools, and produced two reports (Møgelvang et al., 2023; Coelho et al., 2024).

In collaboration with FieldPass[50], a cross-disciplinary project focusing on new ways of assessing practical skills in relation to field and lab work, Simone Lang and colleagues (UNIS) developed certification tools. These tools are designed to assess practical skills in the lab that are commonly assumed to have been learned when taking part in a course—but are typically not directly assessed (Eidesen et al., 2023b). The certification process has also been combined with instructional videos,

leading to improved learning outcomes for practical skills. One example involves assessing whether students are using a microscope correctly. The following description is modified slightly from Lang and colleagues' "teaching and learning toolkit[67]" contribution:

> *Depending on microscope type, the certification is done in one or several steps. As a first step, a presentation on the use of a microscope is given or students watch a prepared video. After that, students get together in pairs and discuss what they just learned. For each certification step, a document (tick-off list) is available providing students with information on what they need to show when being certified. Once confident, they ask the teachers to be certified. During the certification, the students need to explain and show how to use the equipment mentioned on the tick-off list (step 1). The certification can entail several steps depending on the complexity of the microscope. Following step 1, further certification includes work tasks that need to be fulfilled in order to be certified. If students fail during the certification, they can practice once more, and then again ask to be certified. Once they have been successfully certified, they get a tag (we used post-it notes) and can then certify others. They are not allowed to certify the person they initially discussed the material with. Once everyone is done and the 1st assignment is certified, students proceed with assignments 2 and 3. Once the students have passed the activity, they will get a microscope certificate stating which skills they have mastered.*

This successful idea has travelled through bioCEED and beyond, and certification is now used at UNIS, in BIO101 at UiB and similar courses at the University of Oslo.

The bioCEED survey

While we provide many examples of theoretically driven and action research supported by bioCEED in the examples above, we must also describe the achievements of our bioCEED national surveys. Three times—in 2015 (Hole et al., 2016), 2018, and 2023—we conducted national surveys, reaching students in biology-related study programs at nine institutions across Norway. These surveys met many research and information needs, and resulted in several MSc theses, presentations, publications and more manuscripts in preparation. The most recent survey covers the topics of motivation, assessment, field and lab course challenges and benefits, work practices, sense of belonging, test anxiety, and student perceptions of large-language models such as chatGPT.

Sustainability

As the external funding for bioCEED ends, some activities will cease. However, we have made a conscientious effort to think beyond the funding period and to create sustainability plans for centre activities.

Some of the bioCEED products and activities have already become implemented, and thus incorporated into the formal curriculum and the departments budget. A clear example of sustained products are the courses that were initiated by bioCEED and that are now part of the curriculum, such as the practice courses BIO298. Further, many courses were transformed by bioCEED (bioCEED 2014-2023) and will continue in a transformed state. It is difficult now to imagine BIO100 Introduction to Evolution and Ecology without TBL, BIO102 Organismal Biology II without the carbon project or AB-201 without the Learning Arctic Biology platform and the VFGs. In a curriculum-wide sense, the consensus ILOs that were generated during the ReDesign project are now part of the study program. At a broader institutional level, certification as a learning and assessment method for practical field or lab skills has been systematically integrated into both BSc and MSc/PhD courses at UNIS and at BSc

courses at UiO and UiB.

Other initiatives have gradually become supported by the department, for example the student-led biORAKEL tutoring program and the biannual student poster session[68]. The teaching and learning toolkit[69] (Fig. 4.11) is a resource for our colleagues—at UiB, UNIS and beyond—who seek easy-to-implement, tested pedagogical strategies for engaging and assessing their students.

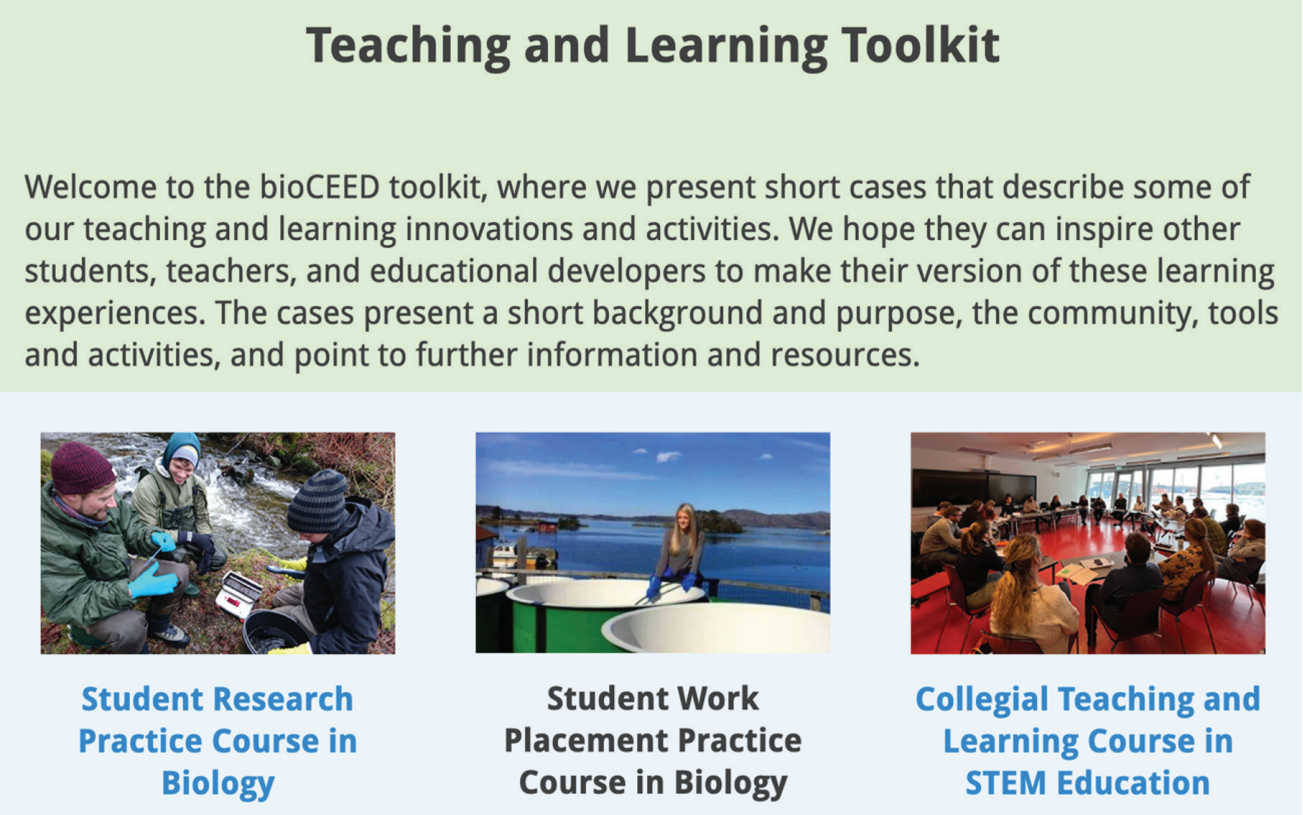


Figure 4.11. *The bioCEED Teaching and Learning Toolkit provides resources for educators interested in adopting some of our pedagogical innovations.* https://bioceed.w.uib.no/resources/toolkits/

Conclusion

In our initial application, we stated that we would "actively support the often called-for shift from a teacher-centred to learner-centred education, and change focus from what instructors do to how students learn." In bioCEED's 10 year Anniversary 6 March 2024, Board Leader Yael Harlap summarized this shift in her introductory remarks. Here, we highlight her concluding remarks:

> *"bioCEED is really radical in that it has positioned students at the centre. We should ALL learn from what bioCEED has done – not just all that it has accomplished but HOW it has worked, what processes have been developed – and I am looking forward to getting more insight into these processes at the rest of the anniversary seminar. I hope that we all go away with the motivation and commitment to continue this work and bring it to other corners of the university – and beyond – so that ALL our students can be engaged in a meaningful, rich, collaborative learning experience as they pursue their degrees."*

In her concluding words, Professor Harlap said so well what many of us have felt about bioCEED's main legacy—that of truly positioning students at the centre of our efforts. It did not happen in the space of a year, or even four. Rather, it was a gradual process that arose out of a growing realization that student-centred teaching—like that we said we aimed for—is really only possible if students are involved as authentic partners, in every step along the way.

List of hyperlinks used in this chapter

43. MNPED660: https://bioceed.w.uib.no/resources/toolkits/toolkit-cpc/
44. ReDesign project: https://bioceed.w.uib.no/redesign/
45. Utvikling av studieprogram: https://mitt.uib.no/courses/30439
46. CALEQ: https://bioceed.w.uib.no/resources/toolkits/toolkit-student-surveys/
47. pedagogical escape room: https://bioceed.w.uib.no/resources/toolkits/toolkit-gamification/
48. ArtsApp: https://bioceed.w.uib.no/artsapp/
49. Teach2Learn: https://teach2learn.w.uib.no/
50. FieldPass: https://bioceed.w.uib.no/fieldpass/
51. bioSKILLS: https://bioceed.w.uib.no/bioskills/
52. bioST@TS: https://biostats.w.uib.no/
53. bioWRITE: https://biowrite.w.uib.no/
54. bioSKRIV: https://bioskriv.w.uib.no/
55. certification: https://bioceed.w.uib.no/resources/toolkits/toolkit-certification/
56. VFGs: https://learningarcticbiology.info/360/vfg/map/
57. Learning Arctic Biology: https://learningarcticbiology.info/
58. bioPITCH: https://clichex.w.uib.no/
59. Soulé et al., 2023: https://bioceed.uib.no/dropfolder/bioCEED/Poster-ISSOTL23-Posters.pdf
60. biannual student poster symposium at BIO: https://bioceednews.w.uib.no/2023/11/29/student-poster-symposium-at-bio-autumn-2023/
61. Kawousi & Barry, 2023: https://kvalitetsbasen.app.uib.no/rapport.php?rapport_id=12078
62. source BIO: https://www.uib.no/bio/150936/studentforskning-gir-ny-kunnskap-om-karbonlagring-i-naturen-i-bergen
63. Atmospheric Infrared Sounder: https://flickr.com/photos/90896682@N06/8265010034
64. Attribution 2.0 Generic license: https://creativecommons.org/licenses/by/2.0/deed.en
65. Bikuben: https://bikuben.w.uib.no/
66. a toolkit entry: https://bioceed.w.uib.no/resources/toolkits/toolkit-gamification/
67. teaching and learning toolkit: https://bioceed.w.uib.no/resources/toolkits/toolkit-certification/
68. biannual student poster session: https://clichex.w.uib.no/
69. teaching and learning toolkit: https://bioceed.w.uib.no/resources/toolkits/

5. Practical Training

Kristin Holtermann, Tina Dahl & Oddfrid Førland
with valuable contributions from the core team

Introduction – from work package to focus area

Increasing the integration of societal relevance and strengthening the work relevance of biology education were key objectives for bioCEED from the beginning (Fig. 5.1).

Figure 5.1. *One of the main goals for bioCEED is to include the whole "biological triangle" in the biology education by giving the students experience with theoretical knowledge, practical skills and tasks relevant to society throughout their whole course of study (Photos bottom corners by Christian Irgens).*

Current developments within the biological sciences are profoundly impacting society, and our vision is that this 'biological revolution' should shape not only the content of biology programmes and courses, but also how biology is taught. bioCEED therefore expands on our existing collaboration to reshape biology education in response to changes in the biological sciences, in higher education, and in society's needs. The new centre will enable development and research-based assessment of learning practices that strengthen the knowledge base, skills sets, and vocational integrity of tomorrow's biologists. The centre will significantly promote sharing of 'best practice' within bioCEED, across the educational sector, and with society.

Vision statement bioCEED (UiB, 2013)

Important aspects of this vision are transferable skills training and work relevance, organized in the original WP *Strengthen links between education and Society* (WP7, UiB 2013), led by IMR. IMR has been key in developing the work relevance programs and the communication with non-academic partners in our work practice courses. The WP7 was later reorganized under the focus area Practical Training (bioCEED, 2017b), and actions are closely linked to other focus areas, in particular Innovative Teaching.

This chapter focuses on the practical work- and research-experience courses designed by bioCEED to provide students with an authentic experience of working as a biologist and applying biology as part of the solution to societal challenges. Other aspects of practical training (e.g. bioSKILLs) are covered in the reflective essays on Learning Culture and Innovative Teaching. In this chapter, we present some core projects in and results within the focus area Practical Training. In addition, we

have included reflective essays from three course teachers and one experienced host and partner, all of which have been involved in developing work practice courses.

PRIME

The project PRIME[70] (How implementation of Practice can Improve relevance and quality in discipline and professional Educations, NFR FINNUT Program) was funded shortly after the launch of bioCEED, and was a collaboration between bioCEED, UiB, NORCE and partners in the private and public sector. Synergies between the PRIME project and bioCEED resulted in novel collaborations between the university and public and private sector that enabled the work practice courses in biology, followed by research on student learning in practice courses, transferable skills training and field work (Hole, 2019).

Developing work placement courses


Talent

Gjør biologi-studenter til yrkesfagelever

Da Universitetet i Bergen fikk ekstra millioner fra staten til å lage en «fremragende utdanning» ble resultatet en yrkesskole.

Teori til praksis

Senter for fremragende utdanning

– Vi ønskjer å finne ut om praksis bør vere ein del av utdanninga i biologi, seier Torstein Nielsen Hole (t.v.) og Gaute Velle.

Figure 5.2. *Excerpt from Dagens Næringsliv Feb. 18th, 2016* [72]

Biology is a diverse discipline that covers a broad range of sub-disciplines, and a variety of specific research skills used in laboratory, field and computational settings. The biology study programmes offer students many opportunities for specialization, but this can also be challenging - particularly for the younger students in disciplinary biology programmes, as they cannot easily picture a straight pathway to a future career. While their peers in professional study programmes (e.g. aqua medicine) do specialized internship courses during their studies to train for a specific profession, the students in the more general BSc program have less obvious, yet many, job opportunities within the public and private sectors, including NGOs, industry and beyond. Therefore, developing relevant work placement internship courses for these students should provide them with a diverse set of internship options in which their biology knowledge and skills are needed. The work placement courses for biology students should also emphasize transferable skills learning outcomes relevant in most future careers. On-campus seminars and student blogs[71] were used to showcase the variety of work biologists are engaged in.

Table 5.1. *Work and research practice courses.*

Course	ECTS	Start (-end)	Number of students/link to resources
BIO198 Workplace practice in Biology II[73]	3	2015-2016	>10 students
BIO298 Workplace practice in Biology[74]	10	2015- still running	>157 students. Student blogs[71]
BIO299 Research practice in biology[75]	10	2004- still running (redesigned in 2017)	>204 students. Student blogs[76]. Posters[77].
BIO297 Field Course Teaching[78]	5	2014- irregularly	>17 students
BIO296 Dissemination project in biology[79]	10	2017-2020	>4 students
AB-207 Research Project in Arctic Biology	15	2016- Paused in 2022	>32 students
AB-208 Internship in Arctic Biology	15	2019- Paused in 2021	>15 students, Student blogs[80].

bioCEED was among the first to start practical work placement courses for discipline-based biology students. This was initially met with skepticism (Fig. 5.2), but the course model bioCEED developed was later adopted by other universities (e.g., the University of Oslo), and bioCEED work placement courses have been a best practice example and presented several times at national conferences.

bioCEED and partners developed and tested a range of practical courses primarily for BSc students in biology (see overview Tab. 5.1), some building on and redesigning existing courses (BIO299 and BIO297) and others developed from scratch (AB-207, AB-208, BIO198, 296, 298). Testing and critically evaluating the courses was essential for the development. The 3 ECTS (European Credit Transfer and Accumulation System) workplace practice course (BIO198) proved to be "too little outcome for too much work". The students did not get enough experience to benefit to any large degree, yet the administration of the course involved relatively high effort. The course on science communication (BIO296) engaged fewer students and overlapped with the courses in work placement and research project (BIO298/299), and science communication projects became integrated as an offer in these larger courses. The 10 ECTS work practice and research practice courses are still going strong and are now a part of the course catalogue as a regular offer to students at BIO, and the Field teaching course (BIO297) is offered on demand. At UNIS, the Research Project in Arctic Biology and Internship in Arctic Biology courses (AB-207, AB-208) have been temporarily paused due to lack of teaching resources, with a plan to be continued. Overview of documentation and assessment of our work- and research placement courses can be found in Box 5.1.

The bioCEED survey

In 2014/15 bioCEED, in collaboration with PRIME, conducted a national survey (Hole et al., 2016) of students, teachers, administrators and end-users (employers of biologists), investigating key features about the status of biology education in Norway. The survey data from end-users informed the development of the work placement courses, both in terms of course content and structure. Survey results were shared with the students, highlighting how employers emphasize the importance of transferable skills training (Fig. 5.3).

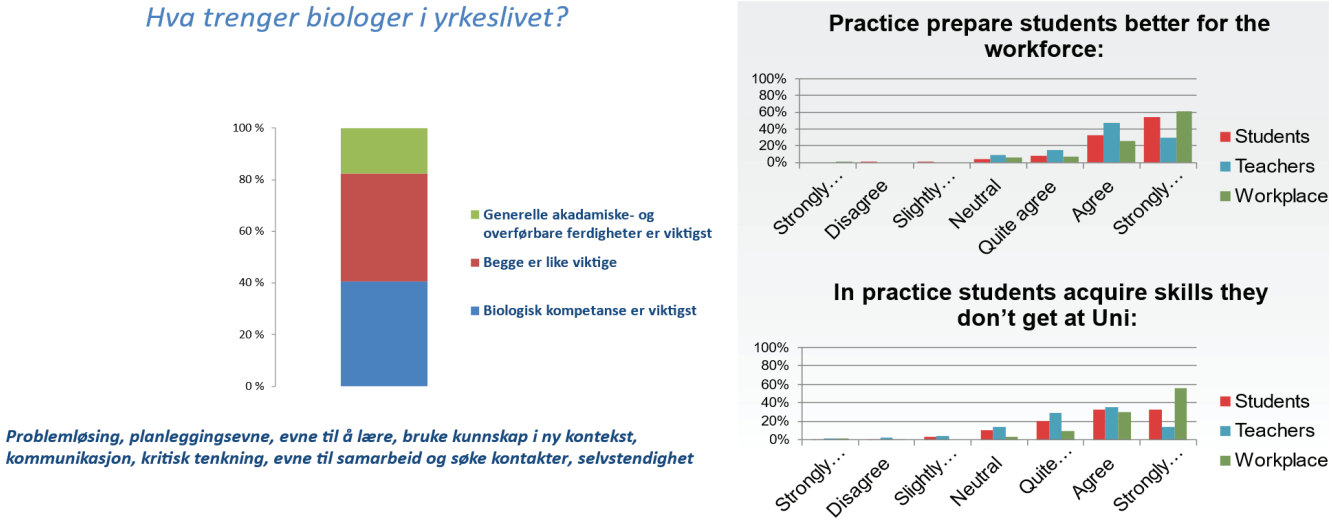


Figure 5.3. *Selected results from the bioCEED survey 2015. Employers value transferable skills (left), and practice prepare students better for the workforce (right) (Hole et al., 2016).*

Reflections from educators and partners on Practical Training courses

Reflections and stories from the students on the Practical Training courses can be found on https://blog.learningarcticbiology.info/ and https://biopraksis.w.uib.no/. Below, three course leaders and one work practice partner and host share their reflections.

BIO298 Workplace Practice in Biology, by course leader Gaute Velle

The BSc level work placement course (BIO298[81]) encompasses two primary components: the work placement and the student's documentation of their outcomes.

The course demands a 250-hour effort from students (10 ECTS), with at least 150 hours at the workplace. Besides the workplace experience, students engage in reflective writing through four blog posts (Fig. 5.4) and a reflective essay, participate in two on-campus seminars, and present their work experience to their peers. These activities are designed to deepen students' reflections on their learning and role as biologists and encourage communication with a broad audience. The reflective essay offers a private space for deeper insight and critique that is shared only with the teacher, and the oral presentation and seminars allow for peer discussion and feedback. Additionally, the course teacher engages with students, sharing insights about the roles of biology and biologists in today's world and transfer learning on campus with learning at the workplaces.

This work placement course was inspired by bioCEED, which posits that biology and biologists evolve through the interaction of biological theory, its practical applications, and the use of biology to address societal needs. Consequently, our biology education aims to equip students for their future roles in both science and society, bridging the gap between academic knowledge and professional identity. This active learning course was initiated in 2015 and allows students to tackle real-life challenges by participating in authentic workplace activities, enriching the elective biology curriculum with practical experience. Having taught and interacted with approximately 200 students over the decade, I have gained significant insights, which are shared below. I emphasize that these are my personal reflections.

Students often note the responsibility and the challenge of assessing quality in their roles as pivotal experiences. They engage in real tasks at the workplace and appreciate the authenticity and potential for real consequences in their tasks. This contrasts with the safety of campus exercises. Such a responsibility can be surprising and scary. However, I have had no negative feedback from students concerning a weight of responsibility. Instead, this exposure fosters a sense of responsibility and intrinsic motivation for learning, despite the initial apprehension. Moreover, students learn to navigate the subjective nature of "quality" in their tasks, balancing it against time and other practical constraints.

Initially, they often worry that they have a lack of knowledge, but soon realize that not knowing is okay, as long as they can learn. They value mastering routine tasks as much as, if not more than,

Figure 5.4. Student blogs

specialized tasks. Some students experience a dichotomy between academic learning on campus and workplace application, feeling that campus education sometimes oversimplifies or inaccurately represents the real world with its demands. Post-placement, students report a heightened ability to apply their knowledge and identify further learning paths.

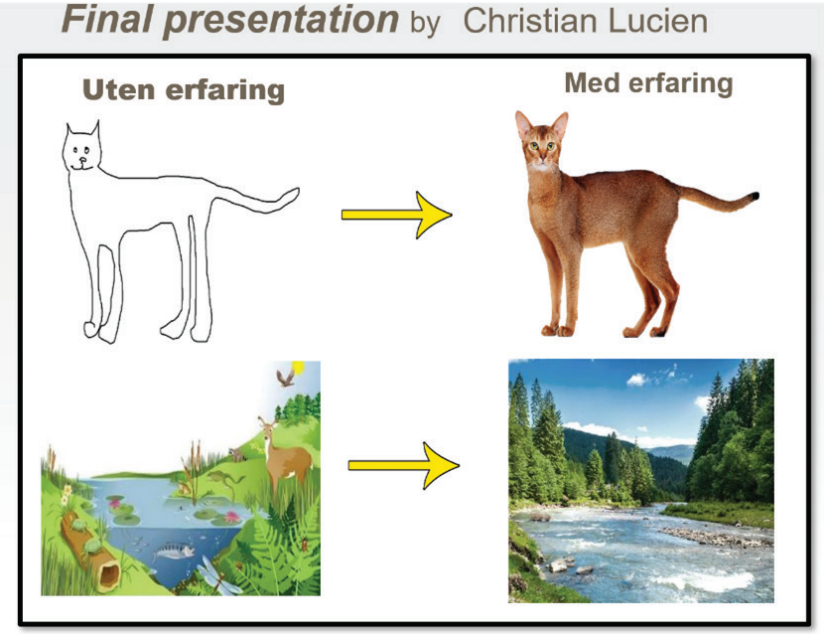


Figure 5.5. Work practice student Christian Lucien's illustration on how biology is perceived with and without practical experience.

In conclusion, the work placement course has proven invaluable for students' skill development and personal growth, offering insights and experiences that traditional academic settings cannot provide (Fig. 5.5). Students deepen their biological knowledge and understand the interplay between various skills and the motivational power of responsibility.

AB-208 Internship in Arctic Biology, by course leader Pernille Bronken Eidesen

Following the model of the work-placement course offered at UiB, UNIS designed the course "Internship in Arctic Biology" (AB-208). To integrate this course into the UNIS course portfolio, it was necessary to expand its scope to 15 credits (ECTS). As a result, the course included a 240-hour internship and spanned over an entire semester. In addition to fulfilling their responsibilities to their internship-hosts, the students had to join seminars at UNIS once or twice a month. These regular seminars served dual purposes. The main objective was to aid students in their "learning-by-working" process, by providing tools to reflect and document their internship experiences. Furthermore, these meetings also addressed various aspects of professional work-life including making CVs, preparing job applications, and conducting simulated job interviews through role-plays. The students documented and shared their experiences online through a format of their own choice, including written blog posts (Fig. 5.4), video-blogs or podcasts (https://blog.learningarcticbiology.info/).

I was course responsible for AB-208 from 2019 until I left UNIS in 2021. Guiding these students through the semester and observing their personal development was both interesting and rewarding for me, and a great learning experience for the students. Initially, it was somewhat challenging providing enough relevant internship hosts within such a small community like Longyearbyen, and I was worried that the internship tasks would not be relevant enough to fit as an "Internship in Arctic Biology". However, this turned out to be a minimal issue. It fast became evident that although some of the internships did not require deep knowledge in arctic biology, the students still gained highly valuable practical experience and new knowledge from being part of an authentic work environment. When the students were asked to reflect on how they applied their subject knowledge in practical scenarios at their workplace, most students managed to reveal important connections.

In addition to the work experience, their sharing of experiences in seminar sessions provided an important learning platform, where students gained insights from their peers. The diversity of the internships contributed to the richness of our seminar discussions. I believe a significant factor in the course's success was this blend of practical internship experience, along with our facilitation of

discussions and activities. This allowed the students to articulate their learning and discuss solutions to various challenges in their workplaces. This course structure played a crucial role in enhancing the applicability and transferability of their acquired skills and knowledge.

Student work practice, by bioCEED core team member and experienced host, Gro I. van der Meeren, Institute of Marine Research

After ten years of experience with meeting and working alongside students in work practice from the UiB course BIO298, the experience is good. The progress in such relationships, from when the invitation is delivered to the student to when workplace evaluations are done, can be listed in sections:

- Preparation at the workplace and the first meeting with the student(s)
- Introducing the student to the actual workplace and planned work tasks
- The first days at work for the mentor and student
- Working into the routines
- Summary of what factors are particularly important for a successful praxis period

This is my experience from my own mentorship and as part of the bioCEED core team.

Preparations

The perfect process is for the host to deliver a fully descriptive invitation about the host, the tasks to be done, and what expectations they have to the student they hope will join their working team. It is sometimes difficult for a workplace to prepare and deliver invitations in time, and with sufficient information about the job tasks for students to fully understand the expectations of the host. It has sometimes been a surprise for the host to learn the strengths and the weaknesses of a student, in particular the years before the students prepared a CV. Also later, an incomplete CV could lead to the work place finding that expectations were not met, leading to additional work load for the host to redesign the plans according to the students actual qualifications.

Introduction

If the invitation was a good description and the students fit the workplace expectations, both host and student will enjoy and benefit from the time and work together. Already at the first meeting between the student and the host at the workplace, it is possible to get a feeling of how well the match is. Even if the administrative formalities to join a professional workplace may be overwhelming, the observant host can get an idea of the student's ability to adjust and integrate in the workplace environment. Even if the host is excited and nervous before this first meeting, the students will be more anxious. How well the student responds to this out-of-comfort zone should tell the host how much novel information and tasks this particular student may handle in the first days. It is important in this phase to help the students to relax and feel welcome.

The first days at work

A student who picks up security rules and understands the aim and goals of the host company and suggested tasks, will gain more trust from the host. A satisfied host will give positive feedback to the student. The first days may open for a rewarding, two-way beneficial, practice period.

Some students meet the host with expectations that are not met and will be dissatisfied. These students can still have a good experience at the end of the practice period, if working with a patient mentor, providing them with more insights and understanding for the actual tasks they are given.

No matter what the students expect, guidance and support from the host mentor is important in this phase.

Into the routines

A well run and predictable working day/week will help the students to fit in the workplace team. For some hosts, this is not possible, as working with biology can mean working with live animals. In such cases, surprises may occur. Every day may involve sudden changes in plans. For some tasks, the routine can be experienced as boring and dull, repeating the same procedure. This is the phase where the host mentor experiences how the students develop and gain insights, no matter what kind of task they do. When the connection between workplace and student is good and full of trust, this is where the students feel they can excel. If not, it is important for the host mentor to provide back-up for motivation. Some of the most demotivational factors seem to be not understanding the importance of the task at hand, the feeling of being overlooked or seen as a burden for the rest of the work team. Again, the responsibility is on the mentor to look after and support the student. Still, some students are not able or willing to do their part. It is therefore important that the course leaders can be contacted for dialogue on what to do if the student turns out to be misplaced.

Summary

A successful practice period can be recognized by a satisfied student, with better insight into their own abilities, new skills and perhaps even a professional network. At the same time, success is a satisfied host and mentor, impressed by what an untrained student can achieve. To achieve this, there are some general factors that need to be in place. First, the expectations of both student and host need to be realistic and the tasks recognizable from the description of the invitation text. The student CV needs to be sufficiently detailed on the student's skill and qualifications. Further, the introduction and guidance from the mentor at the host company should be clear, understandable, and informative. The mentor must be observant and learn the limits of what to ask from the student. Some students take any task and do wonders. Others need to be taught how to do tasks. The hosts need to be aware of the variation of student qualifications at this time of their learning process. If certain qualifications are mandatory for the planned tasks, this must be clearly expressed in the invitation. Finally, the core of a successful practice period is communication, from the written invitations and CVs, to the workplace reports and work certificates, and the day-to-day dialogues in work in between. This also includes the dialogue between the host and the course leadership.

Research as a learning and teaching arena (BIO299) – by course leader Vigdis Vandvik, as part of her reflective teaching portfolio

Offering research-based education is a long-standing ideal of universities. The concept is often understood primarily in relation to content (i.e., the course is based on the latest knowledge), whereas the potential of research as a learning arena where students can develop their knowledge, skills, and competences more broadly has been less in focus (Fig. 5.6). I now expand on this theme through the lens of our research practice course BIO299. For many students, this is the first time they encounter 'real' research in the wild, and I have observed first-hand how strongly many students respond to the experience. They learn the research methods and material pertaining to their project, but they also get engaged, often concerned, about issues such as data quality and project outcomes, and they enjoy but can also struggle with relations to supervisors and collaborators. From the onset, the course was centered on individual student-supervisor interactions, with little scaffolding from BIO's side. This, I felt, was a missed opportunity.

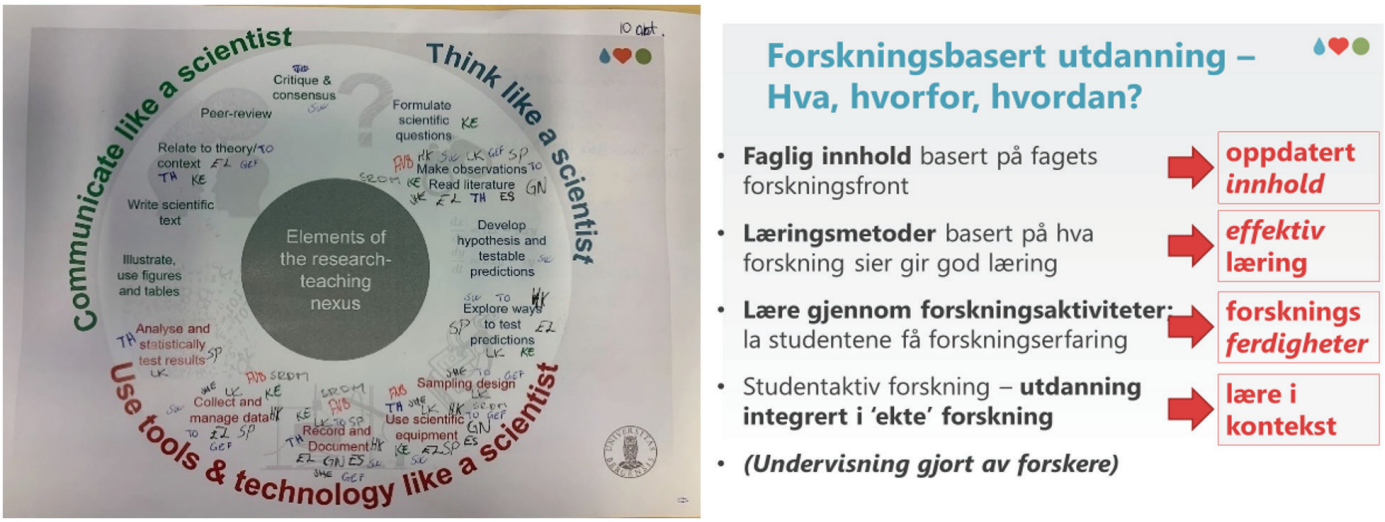


Figure 5.6. *(right) A slide from the introductory BIO299 class meeting, where we discuss *what* research-based education is (and what it is not) and how they can expect to benefit from this course, and (left) the 'wheel of science' annotated by the BIO299 students in October 2022 to illustrate what research activities they have engaged with over the past month. This forms the basis for our class discussions around what science is and what they have learnt.*

When I took over as the course leader in 2017, I started developing the course with the overarching goal of making more space for the students to reflect, and developing learning outcomes beyond research content per se. First, I took hold of the course start-up meeting, adding a broader "why" to the motivation for offering this course, and asking the students to reflect on what they were aiming to achieve, how they thought they would go about it, and what they expected from us and their supervisors. The structure of this seminar (and other seminars I later developed) was a short 'setting the scene' presentation from me, followed by questions that the students would respond to (as this was during the pandemic, we used the annotate function in Zoom to allow the students to scribble their comments online).

Taking these comments as a starting point, the class then reflects together on broader issues and shared learning points emerging from these comments. We also added a course poster session to give students an opportunity to present their research to each other and the supervisors, and a blog to give students a space for reflecting and communicating over meta-perspectives. The feedback from students was strong and immediate - this was all meaningful - and I therefore went on to revise the course description to make more space for such meta-perspectives by building them explicitly into the course ILOs. In the following years the course went through an iterative development, I added more seminars focusing on the 'meta' issues in the new course ILOs (research ethics, supervision, science communication), with specific content developed in communication with the students. Each seminar follows a set structure; students prepare through a task (read a paper, take an online test, etc.), I give a short introduction, the students discuss key issues in class using a simple think-pair-share format, and we then reflect together. My goal is to make the topics relatable by 'scaling' issues from the big (scientific fraud!) to the small (fudging data…) and give students opportunities to take ownership. Students report that they appreciate the seminars as arenas where they can build a community around their research experiences, and also the 'meta' topics and earnest discussions we have.

In connection with each seminar, we also have a short 'around the room' of the students' research experiences since our last meeting. We use the "wheel of science" (Fig. 5.6), which the students annotate with their specific experiences, as a starting point for discussions. Topics that often surface are how to deal with problems or failed experiments, errors in the data, unexpected results, quality control, workload, etc. In one of these sessions a student expressed dissatisfaction with time management; they

wanted a stricter schedule and more deadlines. I thus developed a Gantt chart where I enter the course activities, but where students plan their own work timeline (with supervisor) for the research activities. The idea is to help students plan and structure their work by giving them the tools to organize to be accountable, not by doing this work for them.

The main 'scientific product' delivered in BIO299 is a scientific report in a format agreed upon with the supervisor. To provide more scaffolding and better alignment the course report has been expanded to a portfolio assessment that now contains (i) the scientific report along with (ii) project agreement with the supervisor, (iii) project plan (iv) data sharing agreement, (v) list over working hours, (vi) poster (vii) peer-review feedback given and received, and (viii) ILOs (See course page[82]). These additional elements are specifically designed to constructively align ILOs, course content, and assessment, and allow the students to engage, share, reflect, and feel as researchers with agency and competence (see student blogs[71] and posters[77]). Developing the course required clarifying ILOs, and as it was also apparent that many students were putting in a lot of effort, I wanted to provide more feedback (and credit). I therefore adopted A-F grading and developed an assessment rubric (can be found here[83]) to ensure that criteria were clearly communicated to students and supervisors (as they grade the scientific report; I grade the rest of the portfolio). This was well received among students and supervisors. I am excited to report that we are now getting requests from beyond BIO and UiB with interest in learning about these experiences, and we have therefore developed an online toolkit[84] with a detailed description of the current version and access to all course tools and artifacts.

New plans and collaborations

Building on the novel experiences bioCEED had with the work placement courses, new projects and collaborations have emerged. The project DEVELOP[85] is a 3-year project funded by HKdir, in which bioCEED initiated the collaboration with the SFU iEarth, the work placement courses at UiB, UiO and UiT, our project partner IMR, and the University of Minnesota. The aim of the project is to develop online resources[86] for work placement mentors, based on the needs assessment gathered from focus group interviews.

Further, bioCEED has conducted a national survey in collaboration with UiB, UiO, UiT and Fiskerihøgskolen (UiT) to survey work placement student alumni in STEM discipline programs, and will develop a manuscript for publication based on these data. Additionally, we have initiated a collaboration through a Nordic network seeking funding for discussing and disseminating best practices in work placement courses. None of these additional initiatives would have been possible without bioCEED's successful efforts at course development and design-based research

Conclusion

In the bioCEED focus area *Practical Training*, a major emphasis has been put on developing work placements practice courses for BSc students, and disseminate the results and experience. Our experiences have been valued and have guided development of similar courses at other higher education institutions. The course development and resources have been documented and shared through publications (Velle et al., 2017) and online toolkits (see Box 5.1). In the DEVELOP project, we gain further knowledge about the practice mentor/host experience, and resources for external partners are available at the project webpage and praksisveileder.no[87].

The recommendations for developing practice courses shared in this chapter are based on our ten years of experience, and include knowledge-based course development involving end-users such as partner organisations, practice mentors and students, to ensure alignment in content, practice and

expectations. We wish to highlight that a successful course must be beneficial both for the students´ learning and for the external partner providing authentic work tasks. Further, we recommend a course design with a pedagogical frame of the practical training and learning outcomes that emphasize the transferable skills as more than an "added value" to the practice experience. Finally, a strong link to other educational practices and the specific features of the discipline is imperative.

We hope that the resources and examples in this chapter can provide useful and relevant information to other academic communities starting and developing work and research practice within their discipline.

Resources for developing Practical Training

bioCEED made **Teaching and Learning Toolkits**, where the learning resources we have developed and tested are now openly available:

- Student Research Practice Course in Biology describes the development of the 10 ECTS Student Research Practice Course. All resources developed for the courses are available here: https://bioceed.w.uib.no/resources/toolkits/toolkit-bio299/
- Student Work Placement Practice Course in Biology describes the development and resources for the 10 ECTS Student Work Placement Practice Course in Biology. All resources are available here: https://bioceed.w.uib.no/resources/toolkits/student-work-placement-practice-course-in-biology/
- UNISprout/bioSPIRE a student-led initiative giving BSc students a taste of practical biology, through 40 hours field/lab work with a MSc or PhD student: https://bioceed.w.uib.no/resources/toolkits/toolkit-biospire-unisprout/

Transferable skills training is an essential aspect of the practical courses, including developing students' dissemination skills. The student blogs have been a way for students to write about science and their experience to a larger public. Blogs are a mandatory activity in the practice courses and are a way for students to disseminate their projects, and communicate experiences and accomplishments to potential future employers. Other students also use the blogs to learn about different work experiences in biology.

Student blogs (Fig 5.4) are available here:

- https://biopraksis.w.uib.no/
- https://blog.learningarcticbiology.info/

Scientific publications:

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Box 5.1. *bioCEED resources for developing Practical Training.*

List of hyperlinks used in this chapter

70. PRIME: https://bioceed.uib.no/dropfolder/bioCEED/PRIME%20final.pdf
71. student blogs: https://biopraksis.w.uib.no/
72. Dagens Næringsliv Feb. 18th, 2016: https://www.dn.no/utdannelse/universitetet-i-bergen/gjor-biologistudenter-til-yrkeselever/1-1-5582021
73. BIO198 Workplace practice in Biology II: https://kvalitetsbasen.app.uib.no/popup.php?struktur_id=36799&rtype=fs_desc&kode=BIO198&year=2016&sem=h&popup=0
74. BIO298 Workplace practice in Biology: https://www4.uib.no/emner/BIO298
75. BIO299 Research practice in biology: https://www4.uib.no/en/courses/BIO299
76. Student blogs: https://biopraksis.w.uib.no/category/bio299-forskningspraksis-i-biologi/
77. Posters: https://clichex.w.uib.no/category/bio299/
78. BIO297 Field Course Teaching: https://www4.uib.no/emner/BIO297
79. BIO296 Dissemination project in biology: https://kvalitetsbasen.app.uib.no/popup.php?struktur_id=47010&rtype=fs_desc&kode=BIO296&year=2020&sem=v&popup=0
80. Student blogs: https://blog.learningarcticbiology.info/tag/ab-208/
81. BIO298: https://www.uib.no/bio/84959/yrkespraksis-i-biologi
82. See course page: https://www4.uib.no/emner/BIO299
83. here: https://bioceed.w.uib.no/resources/toolkits/toolkit-bio299/
84. online toolkit: https://bioceed.w.uib.no/resources/toolkits/toolkit-bio299/
85. DEVELOP: https://dvlp.w.uib.no/
86. online resources: https://praksis.w.uib.no/
87. praksisveileder.no: https://praksisveileder.no/

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