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DigitalMarine: an online platform for blended learning in a marine experimental biology module, the Schmid Training Course

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Abstract

For over 20 years, the Schmid Training Course (STC) has offered unique opportunities for marine biology students from European universities to learn about marine model organisms. While the topics of the course have continuously changed over the years with the advent of new research techniques and discoveries, the pedagogical approach has remained largely the same – a combination of lectures, lab practicals, and field excursions. Several life science researchers, who have taught in the STC for many years, sought to bring the course's pedagogical approach into the 21st century, and with the support of Erasmus+ Programme of the European Community funding, the DigitalMarine project was developed. DigitalMarine began in 2018 as an international partnership between the six research centers from which the STC instructors hail, and its main objective was to introduce a flipped, blended approach to learning and teaching with respect to established and emerging marine biological model systems. The DigitalMarine platform, which covers 12 marine model organisms, is now publicly available.

The Schmid Training Course (STC)

The Station Biologique de Roscoff, a marine station of Sorbonne Université (SU), in France (Northern Brittany) was founded in 1872 by Henri de Lacaze-Duthiers with the aim to develop a laboratory for both observational and experimental zoology. Since then, research has extended into additional fields, including ecology and oceanography, and several training courses linked to these areas have been established. One of these courses is the Schmid Training Course (STC) that focuses on experimental biology using marine organisms. The STC was named after the Swiss zoologist Volker Schmid, who was an iconic teacher for the course, and who passed away in 2008 ^[1].

The STC allows students to explore the diversity of marine model organisms and train them in using these models in experimental biology. More precisely, the goal is to show students the benefits of various marine organisms as alternative or complementary systems to the conventional model organisms (*i.e.* *Drosophila melanogaster*, *Caenorhabditis elegans*, *Mus musculus*, *Saccharomyces cerevisiae*) to address fundamental scientific questions.

45 Thus, the course covers regeneration and neurosciences as well as evolution, developmental biology and cell cycle
46 regulation and all their interdependencies. This has been and continues to be a unique interdisciplinary scientific as
47 well as a multidisciplinary pedagogical approach.

48 Historically, the STC has been defined by certain characteristics that differentiate it from other marine biology
49 courses. One of these characteristics is the student experience of immersion in a marine station environment. Classes
50 taught in marine stations benefit from the availability of marine model organisms on-site, and students are invited to
51 collect, observe, and experiment on them, as if they were conducting their own research. In other words, the hands-on
52 practical approach is a fundamental part of the STC experience. Another characteristic of the STC is the large quantity
53 of time dedicated to lecturing, due to the significant amount of theoretical knowledge needed to fully benefit from
54 learning the experimental approaches. The number of lectures means that students are confronted with an enormous
55 amount of information in a relatively short period of time, which is not always evident. Additionally, another characteristic
56 that has proved to be particularly challenging for students is the multidisciplinary aspect of the course, as it requires to
57 integrate knowledge in morphology, physiology, genomics, marine biology, evolution, cell biology, and developmental
58 biology. Due to their heterogeneous backgrounds, students frequently lack basic knowledge in one or more of these
59 areas, which sets them up for a more difficult learning experience and necessitates extra efforts to attain all of the
60 learning objectives.

61 Our team of instructors belonging to six research centers [Sorbonne Université (SU), Università del Salento,
62 Université de Fribourg (UF), Stazione Zoologica Anton Dohrn (SZN), Stiftung Tierärztliche Hochschule Hannover
63 (TiHo), and the Australian National University (ANU)] has been very motivated to alleviate these challenges and to
64 allow students to take full advantage of the intensive research course environment at the marine station. As such, we
65 have chosen to experiment with flipping and blending the course to facilitate students' learning prior to the course,
66 allowing them more time to work at the bench, work in groups, and design individual projects. Before we present the
67 flipped and blended approaches that have been put into place, we will define and describe them in the following section.

68

69 **Flipped and blended approaches**

70 The terms “flipped classroom” and “blended learning” are sometimes confused or used interchangeably, which
71 is incorrect. “Flipping” a classroom refers to changing the classic modality and roles of teaching and learning, that is to
72 say a professor lecturing in class and students acquiring most of the knowledge here in a synchronous manner (Fig.
73 1a). In a flipped class, part of the learning content is acquired before the class (thus asynchronously) as a required
74 preparation, and as such, more in-class time can be dedicated to higher-level and more active forms of learning
75 (applying concepts, questioning, discussing, analyzing, and so on) in order to deepen the understanding of the subject
76 matter^[2]. As the students are given greater responsibility for their learning ahead of the course, their in-class experience
77 becomes more active and they become agents of their own learning during the entire course. It should be noted that a
78 flipped classroom by definition does not necessarily require the use of online materials for learning at home, which is
79 where blended learning comes in. “Blended learning” refers to the use of both online and in-person spaces for the
80 learning to occur. In contrast to a course in which learning supposedly happens only in the classroom, in a blended
81 course students learn in-class as well as outside of the classroom using an online platform that hosts most of the
82 learning material^{[3][4]}. A blended classroom is often flipped too, as online materials are generally being used by students
83 before in-person, in-class interaction with teachers.

84 The interaction of these two pedagogical approaches means that the students can acquire knowledge before
85 class at their own rhythm (asynchronously) through a variety of online learning material (videos, animations, readings,
86 and so on) instead of learning all the course material through in-class lectures. This way students are able to see how
87 well they have understood the material before coming to class, thanks to tools like online formative evaluations that
88 provide feedback to students. For these reasons, setting up a flipped and blended approach is a judicious choice for

89 the STC: the basic required knowledge for each scientific field can be assimilated by students at their own pace and
90 before they arrive at the marine station. Once present at the station, much more time can be dedicated to the
91 experimental work or to set up students' projects and interact with teachers. We thus developed the DigitalMarine
92 platform to elaborate these relatively new learning approaches in the STC (Fig. 1b).

93

94 **How does the DigitalMarine platform work?**

95 *Content of the platform.* The platform consists of an open-access website ([https://digital-marine.sorbonne-](https://digital-marine.sorbonne-universite.fr/index.php/digitalmarine)
96 [universite.fr/index.php/digitalmarine](https://digital-marine.sorbonne-universite.fr/index.php/digitalmarine)) that hosts the majority of the learning material, as well as a private Moodle server
97 that hosts more restricted-access material (research articles, evaluation materials). A total of 12 marine model systems
98 (species and phyla) are presented: acoels, amphioxus, annelids, bacteria, brown algae, chondrichthyans, cnidarians,
99 crustaceans, echinoderms, placozoans, sponges and tunicates (Fig. 2). Among the digital resources, the platform hosts
100 lecture videos, 2D animations, interactive diagrams, marine organism collection and maintenance videos, experiment
101 methodology videos, texts, interviews with guest researchers, links to their scientific communities and links to additional
102 resources for students seeking to learn more about the different model organisms. These online resources constitute
103 the starting point for flipped learning in the course, preparing students ahead of time for in-class activities. In addition
104 to the pages dedicated to each of the 12 marine organisms, the platform has a front page with a presentation video of
105 the platform and short clips of previous STC in Roscoff (SBR) and Napoli (SZN), a page explaining the link with the
106 Erasmus+ programme, a page about the history of the STC, and a presentation page of the researchers involved in
107 both online and in-person phases of the course. The Moodle server also serves as host for other learning resources,
108 such as formative evaluations and provides means of asynchronous communication with the instructors and other
109 students through discussion forums.

110

111 *Use of the platform.* Before the on-site course at the marine station, the platform is freely available for students
112 to access the learning content and familiarize themselves at their own pace. This corresponds to a total amount of 8.30
113 hours of work for students to fully explore the content of the platform. Afterwards, students come to the marine station
114 for the second phase of their learning. As they have acquired most of the fundamental knowledge related to the different
115 marine organisms, more time can be devoted to hands-on lab practicals and discussions with their teacher. **As the**
116 **course relies on both online and in-class learning, we can say it now has a blended approach.** Students are
117 able to access the platform during the course as well, allowing them to re-access material, refresh their memory, review
118 concepts, deepen their understanding, etc.

119 During the in-person session led by their teacher, students also have exercises where they have to “put
120 themselves in the shoes of a researcher”. This is prepared before the in-person class through the platform which gives
121 students background information on the biology of the organisms as well as experimental approaches that are used
122 for their study. Then, at the marine station, the students are given a biological question to investigate and using their
123 prior knowledge, the students suggest several experiments to explore this question; in other words, they have to
124 elaborate a short research project. **This is an example of how the classroom is flipped:** the knowledge acquisition
125 is done at home and the application and deepening of understanding is done in classroom.

126 It is worth mentioning that knowledge acquired by the students during autonomous learning through the online
127 platform is evaluated using **various formative evaluations** (quizzes, questionnaires, written evaluations) provided by
128 teachers. These evaluations are done before the in-person phase of the course using the restricted-access Moodle
129 server (only available to STC students and teachers) or at the beginning of the in-person session. These assessments
130 are fundamental to verify student's learning comprehension in order for them to be able to fully participate in both
131 research exercises and practical lab work during the in-person session.

132 In future editions of the STC, the Moodle will also serve as a means to share students' experimental projects
133 (designs, results) with the group. After the course, the platform constitutes a reference that can be very useful for
134 students during their research internships, should they need to go back to review material that is pertinent to their
135 research field. Note that the DigitalMarine page of a specific marine organism can also be useful for all trainees hosted
136 in the corresponding lab, not only for students doing the STC.

137
138 *Feedback from students.* Students in the STC were able to test a nearly-complete version of the platform in
139 May 2021. Although the platform was not fully finished at the time, the feedback of the students was encouraging. As
140 an example, regarding the question "Did the preparatory work seem coherent with the course objectives, and did you
141 feel well-prepared for the in-person course?" 100% of the students answered positively. A similar score was showed
142 for the question "Did the learning materials provided online (DigitalMarine website and Moodle pages) facilitate your
143 learning during the in-person course?" These questions and other written and spoken feedback from the students
144 indicate that the resources provided by the DigitalMarine platform were clearly beneficial to the students' learning
145 experience.

146 Besides the advantages of these teaching and learning methods for the students, it is worth mentioning that
147 this kind of immersive courses in marine stations or in research institutes constitutes a fantastic opportunity for students
148 to start scientific networking and prospect for future internships or PhDs. Most of the researchers teaching at the STC
149 have hosted a former STC student in their lab. This is also true for other iconic courses in Biology such as the
150 Embryology course at MBL (Marine Biological Laboratory, Woods Hole - USA) or EMBO (European Molecular Biology
151 Organization, Heidelberg - Germany) practical courses.

152 153 154 **Why choose the theme of marine organisms in Life sciences for teaching experimentation?**

155 Firstly, marine stations are in general excellent places to explore new teaching methods as they are
156 environments where student-teacher interactions are easier and more intense, since research, teaching, and
157 experimentation are much more closely connected than in a huge campus with thousands of students. Secondly,
158 courses in marine stations give extra attention to practical lab work, thus any strategy designed to increase time
159 dedicated to experiments is well received. Thirdly, research on marine organisms has contributed to some great
160 advances in Life Sciences but students are not generally aware of the interests of marine models. For example, the
161 green fluorescent protein (GFP, Chemistry Nobel Prize in 2008 ^[5]) was isolated from a jellyfish and is now the most
162 widely used expression reporter for molecular and cellular biology analysis. The pioneering study of the siphon
163 withdrawal reflex in *Aplysia* ^[6] led to the 2000 Nobel Prize in Physiology and Medicine to Eric Kandel. The neural
164 circuitry of this sea slug still serves as the major model of research aimed to decipher the cellular basis of behavior.
165 Finally, the sea urchin model was crucial to discovering cyclins ^[7], essential proteins regulating the cell cycle (Nobel
166 Prize in Physiology and Medicine in 2001). These proteins are conserved in vertebrates and allowed to understand
167 mechanisms responsible for tumor growth in humans, which is a prerequisite to develop therapeutic strategies against
168 human malignancies. These examples illustrate how biotechnologies and biomedical applications rely on basic model
169 system research and how important marine model organisms are.

170 Lastly, marine organisms are part of cutting-edge research such as managing live imaging datasets.
171 Digitalization of datasets like those scored from quantitative analysis of ascidian embryogenesis strengthened the
172 concept that morphogenesis relies on a contact area-dependent cell communication as much as on morphogen
173 gradients ^[8]. In the field of genomics, marine species such as amphioxus have been targeted to examine not only
174 genome sequences but also DNA structures to study regulation patterns that correlate with the transition from non-

175 vertebrate to vertebrate chordates^[9]. We have just seen the beginning of marine models entering the scientific stage
176 to develop new biological concepts and ease high throughput analyses.

177

178 **Conclusion**

179 The STC continues to train future researchers in experimental biology on marine organisms at a
180 multidisciplinary level. The DigitalMarine online platform for the STC has been designed to change the way of teaching
181 and to develop a blended learning approach and this approach will evolve over the course of the different iterations of
182 the STC in the years to come as the instructors experiment with different learning activities, experiments, evaluations,
183 and so on. The use of the platform before coming to the course in marine station is a mean to free up instructional time
184 for a greater emphasis on practical sessions and conceptual discussions with the instructors. This design also provides
185 students with the possibility to learn more efficiently and test their understanding before coming to the in-person class
186 and well before their final evaluation. Ultimately, this teaching and learning approach increases student empowerment
187 and engagement with the course material and learning activities, better preparing them to use marine organisms in
188 biological research in their professional futures.

189

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195 Caccavale, Giovanni Annona and Lorena Buono) without whom running the STC would not be possible. The authors
196 declare no conflict of interest.

197

198 **Author contributions**

199 Haley Flom was the educational engineer for the DigitalMarine project in charge of module storyboarding for
200 each marine organisms. Maja Adamska, Raphaël Lami, Eve Gazave, Salvatore D'Aniello, Bernd Schierwater and
201 Agnès Boutet are part of the instructor team teaching in the STC. They defined the content of their respective modules
202 present on the DigitalMarine platform. The complete list of the instructors is available on the platform. Haley Flom and
203 Agnès Boutet wrote the first draft of this manuscript and all the authors gave significant feedback on it. Figure 1 has
204 been designed by Haley Flom with the input of all the authors. Figure 2 has been designed by Eve Gazave.

205

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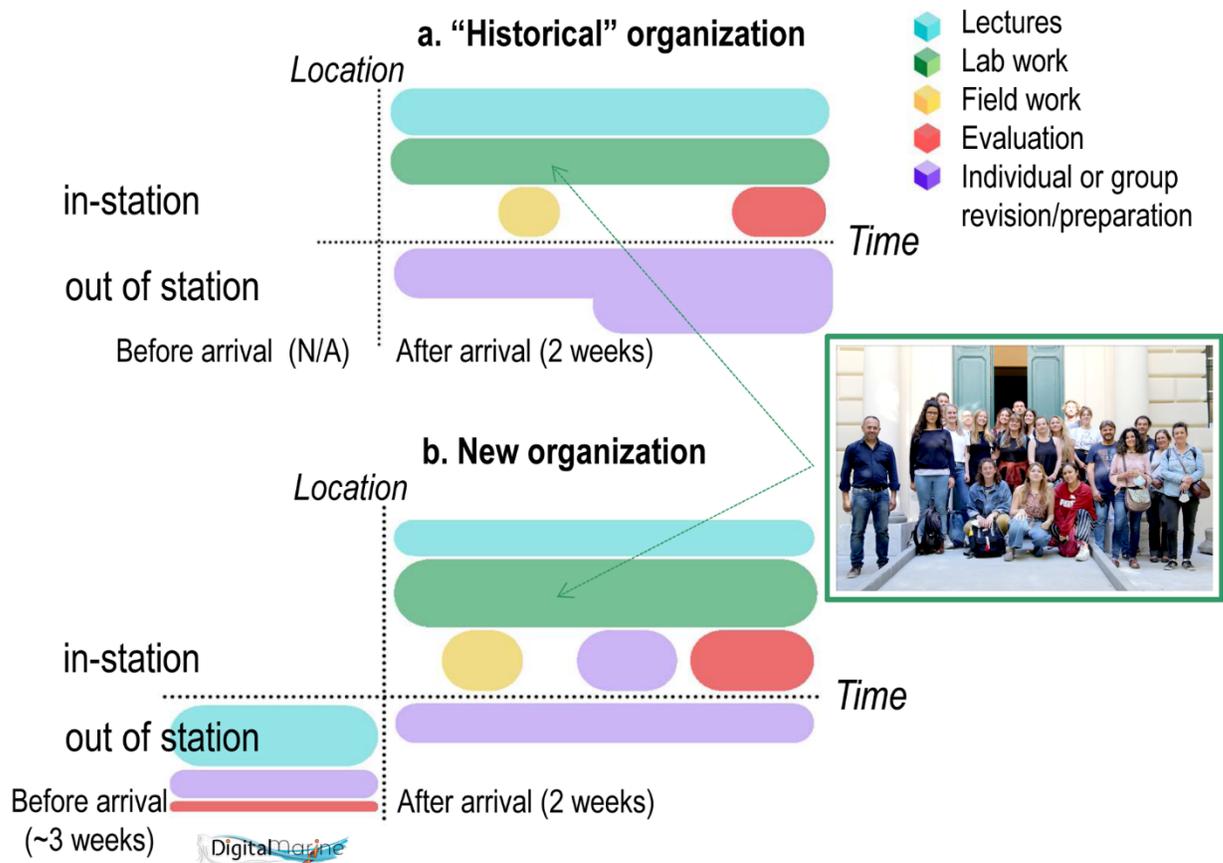
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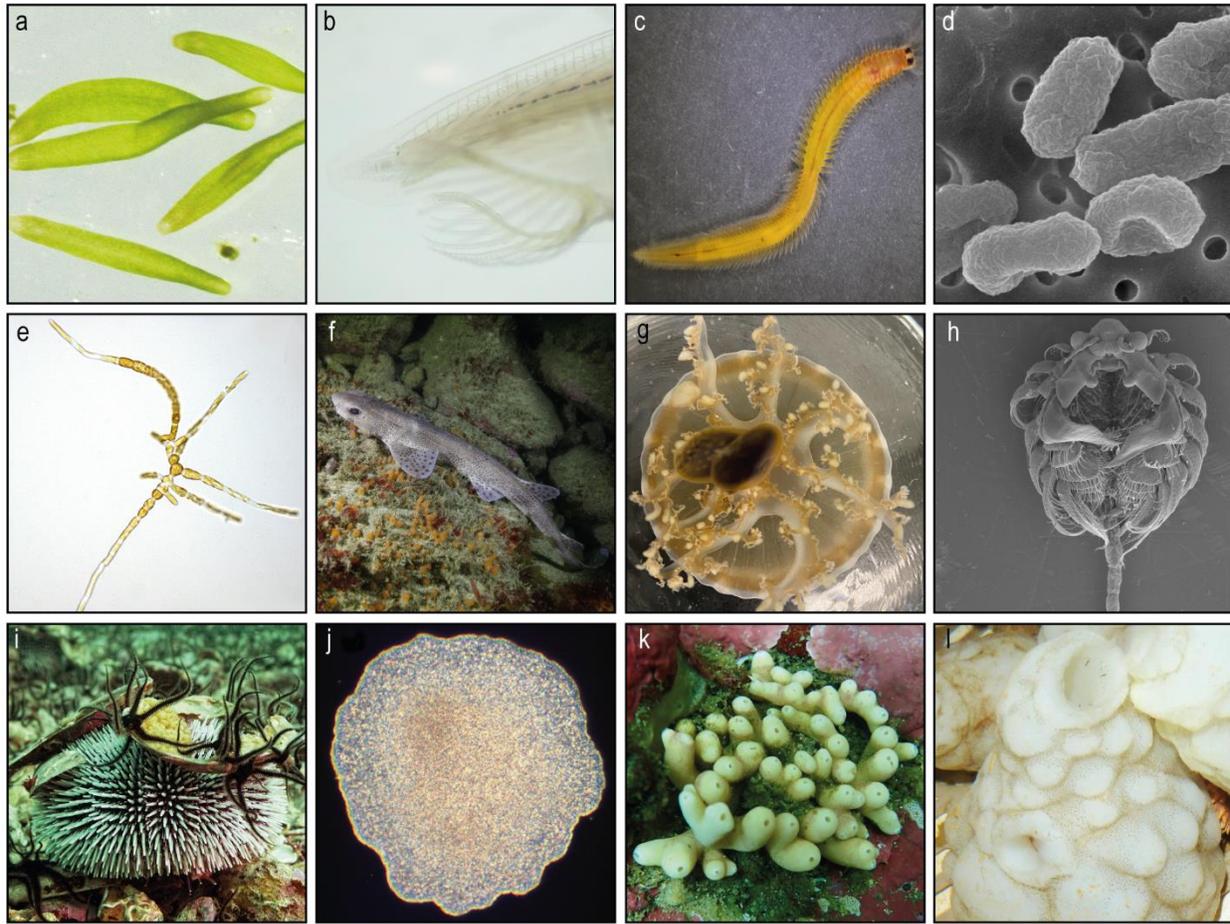
242 **FIGURES**
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Figure 1. Schematic representation of the STC's learning design before and after the DigitalMarine project

a) In the historical organization, no preparatory work is given. Students' days at the marine station are comprised of a more or less equal proportion of lectures and lab work, with a half-day fieldwork excursion and (cumulatively) two half-days of evaluation at the end of the course. All revision of material learned during the day and preparation for the summative evaluations is done in the evening and is typically doubled during the second week. **b)** In the new organization, students are given preparatory work several weeks ahead of the course via the DigitalMarine platform. Their activity is a blend of knowledge acquisition through the online learning material, active note-taking, reading, and formative evaluations allowing them to assess their understanding of the material. Once at the marine station, some time is allotted for lecturing (building on the previously learned content), but a substantial amount of time is allotted to lab work, independent work, plus the same amount of time as before allotted to the field work excursion and summative evaluation. Photo and logo: courtesy of David Wahnoun.



284

285 **Figure 2: “Gallery of portraits” of marine model organisms developed during the course.**

286 **a)** *Symsagittifera roscoffensis* (Acoela), photo taken during the STC in Napoli by the students. **b)** *Branchiostoma*
 287 *lanceolatum* (Amphioxus; Cephalochordata) - focus on the anterior part. Photo taken during the STC in Napoli by the
 288 students. **c)** *Platynereis dumerilii* (Annelida) - Female, photo courtesy of E. Gazave, CNRS. **d)** Scanning Electron
 289 Microscopy (SEM) picture of *Vibrio* sp. (Bacteria), photo courtesy of L. Intertaglia, SU/OOB. **e)** *Ectocarpus* sp. (Brown
 290 algae, Phaeophyceae), photo courtesy of B. Charrier, CNRS. **f)** *Scyliorhinus canicula* (Chondrichthyes), photo courtesy
 291 of W. Thomas, CNRS/SU/SBR. **g)** *Cassiopea* sp. (Cnidaria), photo courtesy of M. Mammone & M. Bilan, University of
 292 Salento. **h)** SEM picture of *Artemia franciscana* (Crustacea) – male, photo courtesy of N. Rabet, SU/UMR BOREA. **i)**
 293 *Sphaerechinus granularis* (sea urchin, Echinodermata), photo courtesy of W. Thomas, CNRS/SU/SBR. **j)** *Trichoplax*
 294 *adhaerens* (Placozoa) – haplotype H1, photo courtesy of B. Schierwater, TiHo. **k)** *Sycon capricorn* (Porifera), photo
 295 courtesy of S. Newson, Crest diving. **l)** *Phalusia mammillata* (Tunicata), photo courtesy of S. Darras, CNRS.