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FarFish

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[1] Document will be a draft until it was approved by the coordinator

[2] PU: Public, PP: Restricted to other programme participants (including the Commission Services), RE: Restricted to a group specified by the consortium (including the Commission Services), CO: Confidential, only for members of the consortium (including the Commission Services)

[3] The initials of the revising individual in capital letters

Deliverable D7.7

Tutor-web educational material ready

27/05/2020

Executive Summary

Training and capacity building are important components of the FarFish project. Among the training and capacity building tools developed in FarFish are e-learning courses that are made available at www.tutor-web.net This document reports on the educational material that has been developed as part of FarFish for tutor-web. The material includes updates of previously existing tutor-web courses that have been tailored for FarFish, as well as new teaching materials directed at FarFish target audience. The material is made available in the tutor-web as a single course, under the heading "Methods and techniques for data-limited fisheries." It consists of multiple tutorials, providing material and drills at various stages of development, on topics from prerequisite mathematics, statistics and programming, through introductory fish population dynamics to methods for data-limited fisheries.

The choice of material is in large part based on discussions, meetings and interviews with potential users.

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1 Introduction

More than 20% of the European fishing fleets catches are taken from non-European waters. Access to these waters is often based on agreements with coastal states that allow the EU fleet to fish from surplus stocks in return for financial support. These agreements have been subjected to criticism, as these fisheries are sometimes poorly regulated and management decisions are often based on limited knowledge, compliance, and enforcement capabilities. It is also too often the case that trust between stakeholders is lacking. The aim of the FarFish project is to overcome these challenges. The FarFish project is designed around six case study areas, in which the European fleet is actively engaged in fishing activities. These are Cape Verde, Mauritania, Senegal and Seychelles, as well as the international high-seas areas in the southeast and southwest Atlantic.

Training and capacity building are important components of the FarFish project. Among the training and capacity building tools developed in FarFish are e-learning courses that are made available at www.tutor-web.net This document reports on the educational material that has been developed as part of FarFish for Tutor-Web. The material includes updates of previously existing tutor-web courses that have been tailored for FarFish, as well as new teaching materials directed at FarFish target audience. The material is made available in the tutor-web under the heading "Methods and techniques for data-limited fisheries." It consists of multiple tutorials, providing material and drills at various stages of development, on topics from prerequisite mathematics, statistics and programming, through introductory fish population dynamics to methods for data-limited fisheries.

The tutor-web system (Stefansson, 2004) has been developed to be a mobile-web system as described by Lentin *et al.* (2014). Within the tutor-web, courses consist of tutorials, which contain lectures. The hierarchy typically contains both material and drills on said material. The system has been used for teaching and educational research and has been demonstrated to enhance learning over and above general classroom instruction (Jonsdottir, 2017).

The system has been developed and enhanced so as to function in locations with unstable electricity and no Internet connection, both in remote areas (Stefansson, 2017) and even in isolated prisons (Njurai, 2017). The system uses a collection of methods to enhance student learning, from personalised drills through cryptocurrency rewards (Lentin and Stefansson, 2018).

The FarFish project has included discussions, interviews and general meetings with potential users and students who need access to training material in fishery science. It has become clear from these discussions that there is a serious need not only for training in the use and applications of fisheries models but also in the underlying mathematics, statistics and use of computers for analysis. For this reason, a fairly wide training set has been brought together and developed for FarFish users.
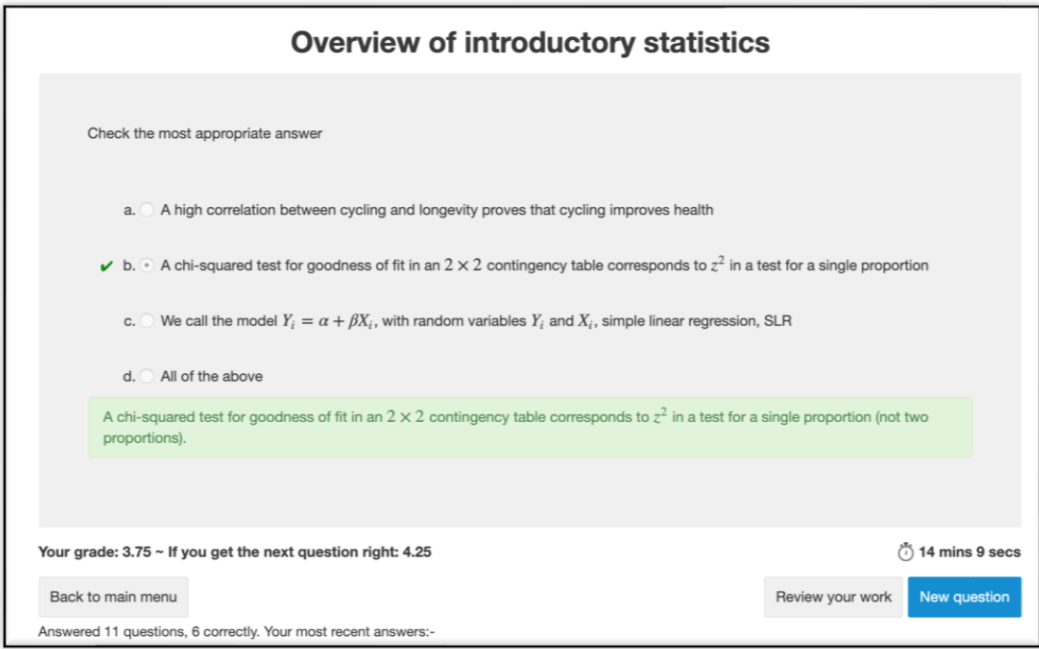
2 The tutor-web drill set

Drills in the tutor-web are accessed in the following manner:

1. Find the tutor-web course
2. Click into the tutorial
3. Click on "Take a Drill" and follow appropriate directions as needed
4. Select "New question", check an answer box and click on "Submit answer"
5. Repeat 4 until requirements set by the real-world course instructor have been met

To test any of the drill sets, one may choose to log in as user **guest** with password **guest**. More detail, with a specific example from this deliverable, is given in a later section of this report.

After a question has been answered, the student's screen looks like the output in Fig. 1.

Overview of introductory statistics

Check the most appropriate answer

    a. ○ A high correlation between cycling and longevity proves that cycling improves health

✔ b. ⊙ A chi-squared test for goodness of fit in an 2×2 contingency table corresponds to z^2 in a test for a single proportion

    c. ○ We call the model $Y_i = \alpha + \beta X_i$, with random variables Y_i and X_i, simple linear regression, SLR

    d. ○ All of the above

> A chi-squared test for goodness of fit in an 2×2 contingency table corresponds to z^2 in a test for a single proportion (not two proportions).

Your grade: 3.75 ~ If you get the next question right: 4.25   ⏱ 14 mins 9 secs

Back to main menu   Review your work   New question

Answered 11 questions, 6 correctly. Your most recent answers:-

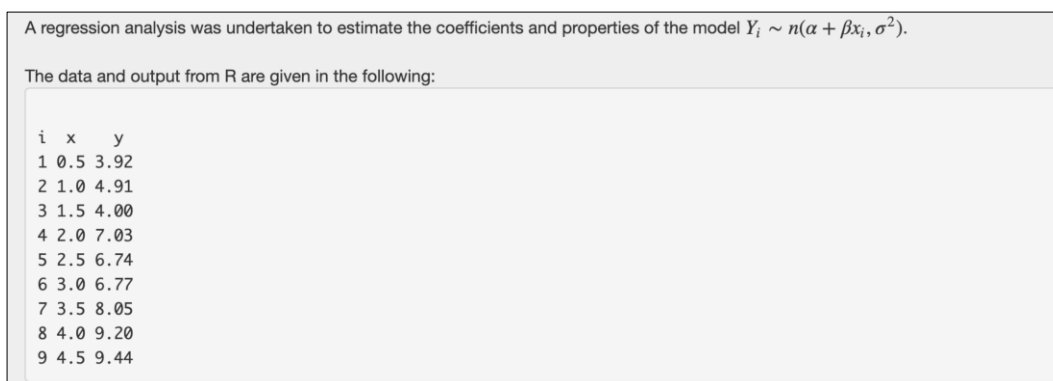*Figure 1: Output from tutor-web after a student has answered a question*

The screen provides the original drill item, with added indicators of how the student responded and what the correct response should have been. Below the item is the student's current grade. For this drill set the timer is set to provide ample time.

Notice how the question in this case is completely generic. It merely takes a collection of correct and incorrect statements and arranges them together in a question.

Notice how this particular question has several distractors. The first (a) examines whether the student knows the difference between correlation and causation. The next distractor (c) is intended to discover whether the student understands that in simple linear regression the *x*-values are constants (measured without error, so not outcomes of random variables).

Finally, the NOTA option (None Of The Above) is included in some questions and not others. There is also an AOTA option (All Of The Above) which is sometimes used. Naturally, there are NOTA+ and NOTA- versions as well as AOTA+ and AOTA-, depending on whether the NOTA/AOTA answer is correct or not. Each of these (NOTA, AOTA or neither) is chosen at random, as is the +/- version, and the randomness ensures that the student does not benefit from guessing.

A slightly different setup is provided in drills on simple linear regression. Here the question has a fairly elaborate header, as given in Figs 2-3. Fig. 2 gives the data and model.

A regression analysis was undertaken to estimate the coefficients and properties of the model $Y_i \sim n(\alpha + \beta x_i, \sigma^2)$.

The data and output from R are given in the following:

```
i  x    y
1 0.5 3.92
2 1.0 4.91
3 1.5 4.00
4 2.0 7.03
5 2.5 6.74
6 3.0 6.77
7 3.5 8.05
8 4.0 9.20
9 4.5 9.44
```

Figure 2: Regression question introduction model and data portion

Fig. 3 then follows by giving a complete set of output from the R statistical package.

```
> summary(lm(y~x))

Call:
lm(formula = y ~ x)

Residuals:
Min      1Q   Median      3Q      Max
-1.24700 -0.08600  0.06667  0.37617  1.06983

Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept)   3.1075     0.5060   6.142 0.000471 ***
x             1.4263     0.1798   7.932 9.63e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6964 on 7 degrees of freedom
Multiple R-squared:  0.8999,    Adjusted R-squared:  0.8856
F-statistic: 62.92 on 1 and 7 DF,  p-value: 9.625e-05
```

Check the most appropriate answer:

Figure 3: Regression question introduction, R portion

Notice how the setup allows the student to do their own analysis from scratch, using a package of their choice. It also allows interpretation of the R output alone with no computation needed; and as before the question ends with the choices, as seen in Figure 4.

Check the most appropriate answer:

a. ○ The slope is significantly different from zero (at the 5\% level) since 0.0000963 < 0.05

b. ○ The number of degrees of freedom for the tests is 7

c. ○ The P-value for testing whether the intercept is zero is 0.000471

d. ○ All of the above

Figure 4: Regression question, typical answer choices

3 New tutorial on data-limited issues

A total of 200 new (FarFish related) drills have been generated and added to the first two lectures of 810.1. These drills are on basic issues such as what models are appropriate and what can potentially be estimated within data-poor scenarios.

There are many misconceptions with regards to data-limited scenarios and it is important to address them before students start their own modelling. For example, it is commonly believed that no age structure can be used in models if there are no age readings and it is commonly believed that area-swept methods will always be reasonable approaches and will not provide overestimates of population size, but both of these assumptions have been demonstrated to be factually incorrect.

A placeholder has been set up for further lectures and drills on data limited methods, with an emphasis on methods currently being developed within the FarFish project.

4 New student-centric educational methods

As part of FarFish, a new version of Tutor-web, currently known as the Tutor-web beta, whilst broadly similar, makes several fundamental changes to the data structures behind Tutor-web to allow several novel features and methods not previously possible. The Tutor-web beta has been used for six lecture courses thus far, to test and refine the additions featured below.

4.1 The need

Students commonly complain that methodology is taught with no reference to their field of study. Multiple-choice drills may enforce mere rote learning. Peer-evaluation may lead to grade inflation. The methodological development reported here addresses these issues directly.

4.2 Open-ended (peer-reviewed) student responses

Drills in earlier versions of the tutor-web have included some features in addition to the usual multiple-choice drills. Thus, a parameter could be set so that within a lecture or tutorial, students would occasionally be asked to author and submit a new drill, or to peer-review such a response.

In these previous versions of the tutor-web, any questions to be answered for a lecture were presented in a linear fashion, with the system choosing what a student could do next, with its decisions guided by the Item Allocation Algorithm. Whilst this was very effective for choosing drill questions for students to answer, students did not appreciate the lack of warning when Tutor-web decided it was time to write a question.

4.3 Lecture stages

The new, beta-version of the tutor-web breaks up a lecture into separately graded stages. A teacher can make a lecture out of any number of stages. Common examples are:

- Answer questions (drill items) on the topic
- Write and review examples
- Write and review questions

A student can choose which stage they want to study in, and can for example return to answering questions if they do not feel ready to write material for other students to review.
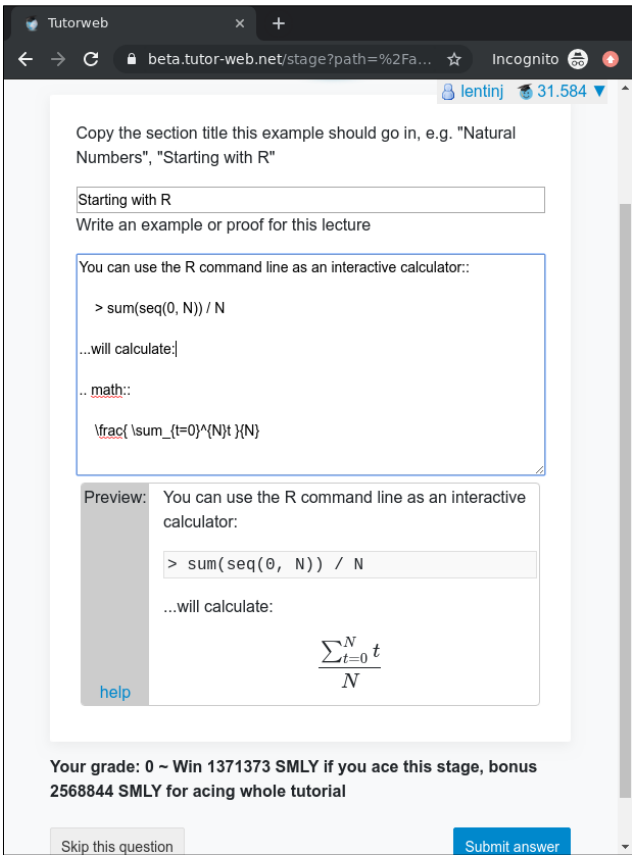
4.4 Tutor-web R generated material bank

A major change for the tutor-web beta is that questions are now defined using R scripts, instead of TeX files. This not only allows many questions to be generated from a single source, but many more options are now made available for question customisation.

Tutor-web beta questions are defined in a material bank, a collection of R functions, each of which can define any number of questions. Each time a student requires a question, an R function will be run with a permutation value, which can be used to generate a particular version of the question. The question can either use the permutation as a seed to choose random numbers to base questions on, select from a question template, or turn on/off workings to make the question easier.

Previously, all tutor-web questions had to be multiple choice. In the tutor-web beta this restriction has been lifted. Material can contain anything that is easily representable in HTML and can be graded in an automated fashion, for example sliders or numerical inputs.

Figure 5: Writing an example in the tutor-web beta

Questions in the material bank are tagged based on their topic and knowledge level required. A lecture stage is then defined by a set of tags, that matching questions should have to be part of a lecture stage. This means questions can be re-used in any number of lectures, so long as tags match. This flexibility has also enabled a separate project SAILS, in which an R package [twstats] was developed to generate questions directly from data sources such as Eurostat (Jonsdottir, 2019).

4.5 Peer reviewed student examples

Tutor-web has been previously used to crowd-source writing question material, where students both write questions and review questions their peers have written with a grade and comment.

In the Tutor-web beta, as material no longer needs to have a fixed multiple-choice format, we can use the Tutor-web to ask students to generate examples as well as questions, where an example is a free-form text box in which students can write a worked example or proof that helps explain a given topic. Students can use ReStructured Text formatting and LaTeX equations, and a preview window shows formatted output as they type it.

The review process has also been overhauled. A student chooses when they want to review material, and instead of grading based on a sliding scale, a questionnaire is provided to gain more insight into what they thought of the material.

The results of this questionnaire are then collated into an overall grade for that example, and finally an overall grade for that stage in the lecture.
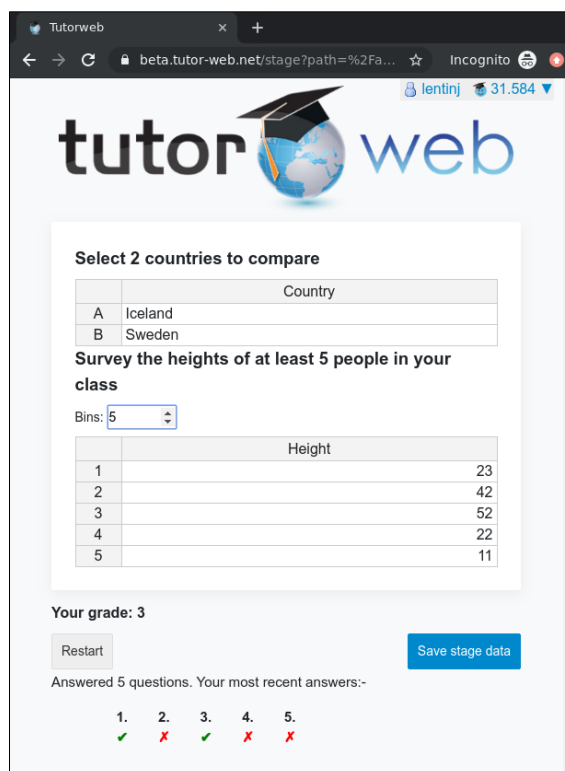
Figure 6: . Student data sets in the tutor-web beta

The student who wrote the question has the ability to see what other students thought of their work, and choose to revise it if need be.

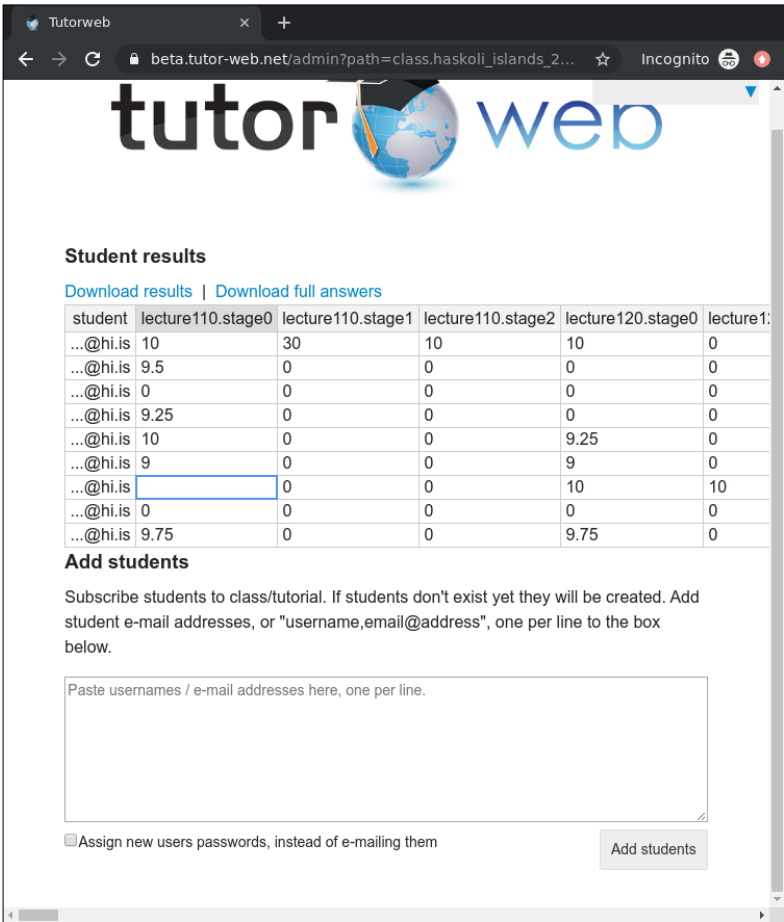## 4.6 Student data sets within Tutor-web

Tutor-web questions can also request that a student provides data which will be used when generating the question. If a set of questions in a lecture all use the same data, it will be requested once at the start of a lecture, so the student doesn't have to repeatedly type out the same data. It will be available as a data.frame whilst the question is being generated.

The format requested from students is flexible, utilising the Handsondataframe packages developed as part of FarFish WP6 (described in D6.5). A question describes the shape of the required data set as a [HODF template], which is then used to generate tables. It is envisaged this set-up can be used in a variety of ways:

- A student can choose from a fixed number of options. For example, they can be asked to choose a country to answer questions on, utilising [twstats] to fetch data for their chosen country from Eurostat.
- A student can provide a series of values based on their own research, e.g. yearly catch data, which statistical analyses can be applied to, and students can work through themselves.
-

4.7 Course administration / integration into other systems

A user on the tutor-web beta can also be registered as a teacher for a given tutorial or class. This allows them to see student progress and transfer data via. CSV into Moodle or any other LCMS.

Figure 7: Reviewing a class' progress in the Tutor-web beta

5 Background stats course

Modern fishery science makes extensive use of statistics, from data displays through highly nonlinear models. Basic courses in statistics teach the concepts needed to interpret the models, but the fundamental concepts commonly do not reach the students. Students typically struggle with p-values and interpretations of outputs from linear model fits. Particularly common are confusion between significance and importance, problematic issues which commonly end up even in peer-reviewed publications and have led to a general disdain for the use of p-values, which by themselves are not the problem if the user knows how to interpret them.

As reported in FarFish D7.3 (Tutor-web FarFish initial setup), the data-limited fisheries course was set up with 7 tutorials, with some to be added during the course of the FarFish project.

The FarFish project has included discussions, interviews and general meetings with potential users and students of fishery science, who need access to training material in fishery science. It has become clear from these discussions that there is a serious need not only for training in the use and applications of fisheries models but also in the underlying mathematics, statistics and use of computers for analysis. For this reason, a fairly wide training set has been brought together and developed for FarFish users. The entire set is seen at https://tutor-web.net/fish/fish850 and given in Fig. 8.

Figure 8: Overview of the FarFish tutor-web course on methods in fishery science

As seen in the figure, with this deliverable (D7.7), a new tutorial (A2: Overview of introductory statistics) has been added to the course. The new tutorial consists of drills in basic statistical concepts. The drill set is developed to address exactly the above issues which students have in understanding fundamental concepts.

The new tutorial has a total of 900 new drill items and most of the examples in Section 2 above are taken from this tutorial. Drills are accessed in the following manner:

1. Find the tutor-web course, at https://tutor-web.net/fish/fish850
2. Click into the tutorial, which leads to https://tutor-web.net/stats/stat201.99
3. Click on "Take a Drill" and follow appropriate directions as needed
   a. respond by logging in,
   b. registering into the system if needed
   c. or subscribe to the drill set
4. Select "New question", check an answer box and click on "Submit answer"
5. Repeat 4 until requirements set by the real-world course instructor have been met

The drill set for this tutorial is set up with 300 questions on simple linear regression (SLR), intended to drill into every aspect of correct and incorrect interpretation of regression output. It also has another 300 questions on interpreting hypothesis tests and 300 on p-values. In combination these new items cover and correct the most important misinterpretations of elementary statistics.

On a pedagodical note, it should be pointed out that although the tutor-web **does** include a course on the use of R, it is not included here. Instead, the focus is on fundamentals, i.e. understanding the basic mathematics, statistics and fishery science along with its applications in data limited situations.

The basic use of R is covered in many other on-line videos and open courses. However, it is also covered as a part of the introductory mathematics tutorial in FarFish (A1: From numbers through algebra to calculus and linear algebra), which covers all the mathematics and programming concepts needed for applied statistics and fishery science. This tutorial is also a good introduction to take before attempting the above intro stats course (and is recommended as a part of a degree, Master of Applied Statistics, at the University of Iceland, or as a general remedial tutorial for graduate students in ecological modelling).

6 Conclusions and discussions

As part of FarFish, a course has been developed and set up on www.tutor-web.net in accordance with the objectives of the project (DoA D7.7). The outline consists of tutorials required for a course on fish population dynamics and utilisation in an ecosystem context in the case of data-limited fisheries. The tutorials contain lectures, which in turn contain drills designed to give students mastery of the prerequisites for assessments for data-limited stocks.

The tutor-web learning management system has been enhanced far beyond other such systems in that it allows an instructor to set up drills specific to class' data and even for each individual student to upload their own data to be used in the drills. The student group can also be asked to write examples and reports which other students are asked to peer-review through grades and feedback. The submitter can subsequently revise the submission and submit for a new review.

The next sub-task in the Tutor-web component of the FarFish project is to demonstrate, test, validate and improve the Tutor-web content. This will be done within different tasks in the project e.g. in T7.5 post-graduate training and T7.6 in-country workshop. The in-country workshop is planned in the autumn of 2020 in Cape Verde (depending on Covid-19). The final step in the process is then an on-site demonstration of the Tutor-web FarFish solution. This will be run as "proof of concept" on the applicability of the solution, which will take place in the Seychelles in early 2021. The task leader will then travel to Seychelles to run a Tutor-web course. He will bring tablets and a server, which will be left behind to be used onwards beyond the project lifetime.

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[twstats] https://github.com/tutor-web/twstats
[HODF Templates] https://github.com/shuttlethread/hodf/blob/master/README.md#templates