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Training hydrologists to be ecohydrologists: a "how-you-can-do-it" example leveraging an active learning environment for studying plant-water interaction

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Abstract

Structuring an education strategy capable of addressing the various spheres of ecohydrology is difficult due to the inter-disciplinary and cross-disciplinary nature of this emergent field. Clearly, there is a need for such strategies to accommodate more progressive educational concepts while highlighting a skills-based education. To demonstrate a possible way to develop courses that include such concepts, we offer a case-study or a "how-you-can-do-it" example from an ecohydrology course recently co-taught by teachers from Stockholm University and Cornell University at the Navarino Environmental Observatory (NEO) in Costa Navarino, Greece. This course focused on introducing hydrology Master's students to some of the central concepts of ecohydrology while at the same time supplying process-based understanding relevant for characterizing evapotranspiration. As such, the main goal of the course was to explore central theories in ecohydrology and their connection to plant-water interactions and the water cycle in a semiarid environment. In addition to presenting this roadmap for ecohydrology course development, we explore the utility and effectiveness of adopting active teaching and learning strategies drawing from the suite of learn-by-doing, hands-on, and inquiry-based techniques in such a course. We test a gradient of "activeness" across a sequence of three teaching and learning activities. Our results indicate that there was a clear advantage for utilizing active learning techniques in place of traditional lecture-based styles. In addition, there was a preference among the student towards the more "active" techniques. This demonstrates the added value of incorporating even the simplest active learning approaches in our ecohydrology (or general) teaching.

1 Introduction

Ecohydrology is an evolving discipline that deals with the interaction between ecosystems and hydrology. Ecohydrology has been a rapidly growing since early work on vegetation and hydrology interactions (e.g. Hack and Goodlett, 1960; Penman, 1963; Eagleson, 1978). Today, ecohydrology still maintains an active and healthy discussion about what forms the core of this emergent field (e.g. Hannah et al., 2007; Wilcox, 2010) and where the future will be found (e.g. King and Caylor, 2010). This rapid growth and discussion on the research side has been mirrored more recently in the associated education. Take, for example, the work by McClain et al. (2012) outlining a potential structure for ecohydrology education. They clearly identify the potential pitfalls and complex challenges associated with teaching and education within ecohydrology stemming from the various disciplines involved.

This creates various "spheres" of ecohydrology that should be addressed in order to train the future generation of ecohydrologist such that they can play a leading role in environmental problem solving (McClain et al., 2012). As outlined in McClain et al. (2012) in this special issue on "Hydrology education in a changing world", these principle spheres consider (i) climate-soil-vegetation-groundwater interactions at the land surface; (ii) riparian runoff, flooding, and flow regime dynamics in river corridors; and (iii) fluvial and groundwater inputs to lakes/reservoirs, estuaries, and coastal zones. Each conceptual sphere (and their interface – see McClain et al., 2012) can bring about its own unique set of challenges that reflect the broad range of topics under the umbrella of ecohydrology. For example, the required flow regime and subsequent dynamics necessary to protect desired ecological functions represent a key focal area of active ecohydrological research (Arthington et al., 2010). Further, much work currently centers on how the composition and configuration of vegetation alter the hydrological cycle across scales in connection with process-level changes due to land use alteration (e.g. van Griensven et al., 2006; Wilcox, 2010). While the research field of ecohydrology abounds with challenges and numerous avenues for potential advancements, the issue still remains how to best address these different "spheres" in practice and, more specifically, in our courses.

This issue is compounded by the inter-disciplinary and cross-disciplinary nature of ecohydrology which can become a challenge in the classroom. Such challenges are longstanding in standard hydrology education due to its inherent interdisciplinary nature (Wagener et al., 2007). This can lead to combinations of intended learning outcomes (ILOs) in courses that may not be easily or completely achieved using traditional lecture-based learning environments or using basic problem-solving techniques (Lyon and Teutschbein, 2011). As such, ecohydrology education and teaching may be better achieved through inclusion of more learner-centered approaches (e.g. experiential learning, inquiry-based learning, and collaborative learning) (Huba and Freed, 2000) and more progressive teaching strategies. These approaches are traditionally considered to fall under the broad umbrella of active learning approaches (Bonwell and Eison, 1991).

Active learning is defined in a general sense as any instructional method that engages students in the learning process (Prince, 2004). As such, active learning requires students to carry out meaningful learning activities and think about what they are doing (and why they are doing it) (Bonwell and Eison, 1991). Such approaches lend themselves organically to natural science disciplines. For example, geography education has seen benefits from more active learning approaches since it has traditionally contained collaborative, hands-on, and experiential learning through lab and field-based learn-by-doing courses (Spronken-Smith, 2005; Levia and Quiring, 2008). In hydrology education, Lyon and Teutschbein (2011) demonstrated how students both preferred and performed better in a problem-based learning environment, which is, by definition, an active learning environment in nature. Shaw and Walter (2012) point to the potential for inquiry-based comparative analysis approaches centered on resolving similarities and differences between hydroclimatic regions to help in linking across disciplines and developing critical thinking within hydrology courses. Given the history of success adopting active-learning approaches in natural sciences and hydrology, it stands to reason that ecohydrology education could also benefit from adopting such approaches. What is yet to be seen is to what extent ecohydrology courses (and all our courses in general) need to be "active" in nature to achieve their goals.

Taken all together, there is clear need for ways forward in ecohydrology education that can include/promote active learning environments. McClain et al. (2012) do a great job highlight an educational framework for training hydrologist to be ecohydrologist. Here, we seek to begin adding details to that framework in the form of potential course structures. Specifically, we present a “how-you-can-do-it” example from a recently conducted ecohydrology course. We consider this a potential roadmap on how to design courses that promote an active learning environment. Further, we test the utility of such an active learning environment (from both the students’ and teachers’ perspectives) for achieving the course goals (which are likely representative of what would be expected from many ecohydrology courses). We also seek to answer the question “How active is active enough?” when considering how to design and structure teaching and learning activities (TLAs) in such a course. This allows us to gauge the added value brought about by inclusion of more (or less) “active” components.

2 Ecohydrology: a Mediterranean perspective

Recently, an international Master’s course was developed by Dr. Steve W. Lyon, Department of Physical Geography and Quaternary Geology, Stockholm University (Sweden) and Dr. M. Todd Walter, Department of Biological and Environmental Engineering, Cornell University (USA) for the Navarino Environmental Observatory (NEO) to explore some of the central concepts of ecohydrology. This course, entitled *Ecohydrology: A Mediterranean perspective* brought together students from both universities to investigate processes driving plant-water interactions in the Mediterranean environment surrounding Costa Navarino where the NEO is located. Students designed and carried out a field experiment highlighting both the location’s uniqueness and potential sensitivity to climatic changes. This provided an excellent opportunity for both the students and teachers to bridge the gap between theory and practice (McClain et al., 2012) by placing the NEO in an ecohydrologic-relevant framework.

The main goal and intended learning outcomes (ILOs) (Table 1) were designed by the teachers to explicitly target central concepts of ecohydrology. Due to the broad and varied concepts in ecohydrology (d'Odorico et al., 2010; Wilcox, 2010) and natural settings of the NEO, the initial offering of this course narrowed in on plant-water interactions. We have uploaded the course syllabus as Supplement to provide a complete overview of the course (including assessment methods and grading criterion). The course was structured to correspond to about 3–4 weeks of teaching time and to be carried out during a summer term following the first sequence of Master's level hydrology education. In the following, we provide a general overview of the course's three main teaching and learning activities (TLAs) (Biggs and Tang, 2007) and the motivation behind them.

2.1 TLA #1: what is ecohydrology?

In this first TLA of the course, students reviewed central concepts of ecohydrology through a combination of state-of-the-science literature review and discussion (see reading list in syllabus as Supplement). The goal here was to build the students' knowledge base around the question "What is ecohydrology?". This first step was necessary in this specific case study example as the general composition of students in the course (i.e. upper level Master's students following a program in Hydrology, Hydrogeology and Water Resources) were unfamiliar with the main tenants of ecohydrology.

Learning in this TLA was designed to be exploratory and self-regulated in nature. Students were presented with some of the state-of-the-science literature relevant for ecohydrology and asked to summarize and synthesis across the seemingly divergent topics. These topics focused on ecohydrology in a general sense, evapotranspiration mechanisms and processes, and hydroclimatic assessments in Greek and the Mediterranean region to provide a site-specific background relevant for this course. Students were encouraged (and required) to explore the current literature on these topics and include their own references (i.e. those not specified by the instructors) as they attempted to answer the central question of this TLA. After approximately one week, students lead discussions on the breadth and interconnections across the literature provided and the literature they gathered. In addition to leading discussion sessions, students were required to complete a short, written summary that could be assessed by the teachers (Table 2). Based on these summaries and the in-class discussion, students were able to identify several central concepts with regards to climate-soil-vegetation-groundwater interactions at the land surface. While student perspectives were clearly guided by the initial assigned literature list and course structure (see Supplement), a general appreciation of the field more relevant for the full breadth of ecohydrology could have potentially been adopted given a wider range of literature. In addition, the free-form discussions allowed for identification of knowledge gaps to be better addressed in next two TLAs in the course.

2.2 TLA #2: calculations of evapotranspiration

This second main TLA specifically targeted providing relevant "tools" for the students' toolboxes such that they could tackle designing and carrying out an ecohydrological experiment to investigate plant-water interaction. Here, we specifically refer to the appropriate theories and methodologies to characterize evaporative fluxes from the landscape. This is in line with the skills-based style of education called for by McClain et al. (2012). In this TLA, students developed relevant hydrologic models (with teacher guidance) to estimate evaporative fluxes using a myriad of approaches. Specifically, we targeted using a water balance (closure) approach, several empirical temperature-based approaches, and traditional energy balance relationships for estimation of potential and actual evapotranspiration relevant for the hydroclimatic setting of NEO. The modeling allowed for investigation of the interaction between plants and water from a mechanistic perspective to exemplify the terrestrial fluxes of water from the landscape. Modeling was carried out in an open computer lab setting with the students encouraged to interact and help each other. The attempt here was to motivate cooperative learning. In addition, the in-class discussions also provided ample, often spontaneous, teaching moments to address knowledge gaps that were inevitable given the short timeframe the students had to synthesize the concept(s) of ecohydrology and experiment with different modeling approaches. These “teaching moments” were also used to help guide the learning process in general.

This TLA leveraged off existing hydroclimatic monitoring collected in connection with ongoing NEO field activities. Students were given about 3-yr of 15-min raw data (always a great first step!). They needed to perform quality controls on these raw data and reduce them to daily information. From this, students were asked to develop a simple water balance (which scaffolds on their previous hydrology courses) and implement temperature-based empirical estimates of potential and actual evapotranspiration (e.g. Langbein, 1949; Turc, 1954; Hargraves and Samani, 1985). Lastly, students developed a full Penman-Monteith (Penman, 1984; Monteith, 1981) estimate of potential evaporation for the NEO site. Rather than teaching this explicitly, students were directed to existing publically available and standard techniques (e.g. Allen et al., 1998) to explore the range of approaches and carry-out the calculations. This allowed students the opportunity to trouble shoot and make the necessary approximations and assumptions required faced with data limitations.

By adopting several different approaches, students were able to appreciate the full spectrum of possible estimates for potential evapotranspiration. Student estimated potential evapotranspiration values spanned the range from about 900 mm per year using the Thornthwaite approach (Thornthwaite and Holzman, 1939) to about 1300 mm per year using the Penman-Monteith approach. These various estimates allowed teachers to highlight the implications and potential limitations associated with the various parameterizations in each approach, the assumptions made when synthesizing across various hydroclimatic datasets, and the potential added value of site-specific estimation. It also allowed for students to explore the potential variability within one given approach (e.g. the full Penman-Monteith method) depending on the values taken for the numerous physical and parameterized relationships in the equation.

2.3 TLA #3: designing and conducting an ecohydrological experiment

This third TLA was carried out in the field at the NEO in southwestern Messina region of Greece. Students were tasked with designing a field experiment to test key assumptions and simplifications relevant to the calculations carried-out in TLA #2 and connect these estimates back to ecohydrological concepts outlined in TLA #1. These include, for example, the selection of a representative value for relative humidity when estimating evapotranspiration given the inherent heterogeneity faced at the landscape scale and the potential impact of diurnal variations on net radiation considered in energy balance estimates. Setting the structure and nature of this experiment was fully in the hands of the students. As such, students were required to self-organize and divide tasks accordingly to design and complete their experiment. This fostered a collaborative learning environment. Teachers provided some general overview and detailed knowledge when necessary (e.g. detailed lectures on Penman-Monteith calculations or demonstrations of how to use field equipment).

During the visit to the NEO (about 5 days in total), students took time to brainstorm ideas for relevant experiments that took advantage of the location's unique features, the available equipment, and their own knowledge base. After an initial break-out style discussion to facilitate the brainstorming, teachers and student convened to synthesize and generate an overarching testable hypothesis with several supporting questions to be answered (Table 3). For the course offering considered in this case study, students centered their experiment around the hypothesis that evapotranspiration would be higher from more-managed locations (i.e. more extensively irrigated) and open water bodies than from less-managed locations (i.e. drip-irrigated and non-irrigated landscapes). To test this hypothesis and answer the supporting research questions, students conducted field measurements to gather data and performed the necessary calculations (Fig. 1). This TLA concluded with student presentations and discussion of the answers to their research questions, the validity of their hypothesis, and potential implications for regional development. This allowed students to collaborate and to place the NEO in an ecohydrologic framework and confirm this placement with field-based experimentation.

3 Methodology

The aforementioned course structure and TLAs were explicitly designed to involve a gradient of active learning strategies. These can be relatively ranked in the following broad sense according to their level of "activeness". TLA #1 offers a low-level of active involvement as students self-guide their reading of state-of-the-science literature and self-regulate their intake of knowledge. TLA #2 can be conceived as a mid-level of active involvement as students work with processing raw data and applying/adapting relevant evapotranspiration equations. Further by having open computer lab sessions where students are encouraged to assist each other, TLA #2 brings in some aspects cooperative learning. Lastly, TLA #3 clearly has a high-level of active involvement as students design and carry out a field-based experiment utilizing a wider range of activities than the other two TLAs. As the students self-organized into a functioning research team to complete the experiment, there was also high level of collaborative learning.

This gradient of active learning TLAs allowed us to gauge the effectiveness of a more versus less active learning environment in an ecohydrology course. Here this was done by assessing students' views of the usefulness of the individual TLAs for achieving the overall goal of the course (Table 1). We also asked the students if the course achieved its overall goal and if they felt the general active learning environment was affective for achieving this goal relative to traditional lecture-based approaches they experienced in other courses. This assessment was conducted using anonymous course evaluations at the end of the most recent course offering (June 2012). During this initial offering, we had an enrollment of 6 Master's level students all of which had completed the first year of the Hydrology, Hydrogeology and Water Resources Master's Program offered through the Department of Physical Geography and Quaternary Geology at Stockholm University. This background education was a prerequisite and created a more-or-less homogeneous prior educational background that likely typifies non-engineering hydrology Master's students most teachers would come across in an ecohydrology course. The demographic distribution of the students was skewed towards female (5 of 6) in this cohort.

Within the context of the written voluntary course evaluations completed at the completion of the course, students were asked to quantify the utility of each TLA and the utility of the over-all active learning environment on an integer scale from 1 (not very useful) to 5 (very useful). We avoided asking specifically about the ILOs as these were more custom tailored and aligned in relation to the TLAs (i.e. we would not expect TLA #3 to help in achieving ILO #1). In addition to quantifying student opinions on the utility of each TLA, we also collected student reflections via open-form comments on the usefulness of the TLAs and the overall active learning environment. Since the small course size and use of student reflections may tend to skew results, we have also elected to include some teacher reflections on the effectiveness of employing an active learning environment relative to more traditional forms of education.

4 Results and discussion

4.1 On the general use of an active learning environment to achieve the course goal

When asked if the course had achieved its main goal, 100 % (6 out of 6) students responded that it had. We considered this as an indication of a successful course. In addition, this (from our perspective) lends credence to the following results and discussions in light of the small sample size considered. When explicitly asked about the effectiveness of an active learning environment relative to a tradition lecture-based environment for achieving the goal of the course, students by-and-large agreed that this environment was useful (to very useful) in achieving the course goals (Fig. 2). Considering the 1 to 5 integer scale as a scoring system, the average score was 4.67

across all students with regards to the effectiveness of the active learning environment. From this simple survey, the students were clearly aware of the active learning environment and also cognitive of the differences with what they had previously experienced in more traditional lecture-based environments. Again, this result helps lend support to the following comparisons with regards to the individual TLAs and their utility in such a course.

4.2 How active is active enough?

Clearly, there was agreement among the students that the more “active” the TLA; the more useful it was in achieving the course goal (Fig. 2). Again, considering the 1 to 5 integer scale as a scoring system, the average score for TLA #1 for achieving the course goal was 3.33 while it was 4.17 for TLA #2 and 4.50 for TLA #3. To some extent, this result could be anticipated based on previous active-learning research in the sciences (e.g. Knight, 2004; Neilsen et al., 2012) and in hydrology (e.g. Lyon and Teutschbein, 2011). As such, it is not that surprising here that TLA #3 where students designed and carried out an experiment would be considered the most useful to achieve the course goal.

What is interesting, however, is that we see clear preference across the gradient of active learning strategies towards the more active approaches. This preference demonstrates the added value we can assign to the effort of including additional active learning in teaching. Further, it highlights that even partial inclusion of active learning techniques have clear benefits. For example, moving from student exploration of literature (TLA #1) to active participation in data analysis and calculations (TLA #2) increased (significant at $p < 0.05$) the utility of the TLAs (and thus efficiency of our teaching) in this course. This is an important results since it demonstrates that while it might not always be an option to immerse students in a full-on active learning environment, such as that fostered by TLA #3 in this case study, there are alternative or incremental degrees of “activeness” that can add value to our courses. This is encouraging for those faced with developing new course in emergent research fields (such as ecohydrology) where the funding or field sites may not yet be well established.

4.3 Student reflections

Students clearly appreciate the feeling of being involved and engaged with their education, which was fostered in the active learning environment. According to one student, it was "*great to be involved from the start and get acquainted to a "scientific approach" of experimentation*." Such engagement tends to promote deeper learning approaches (Biggs and Tang, 2007). The students were aware of and confirmed that deeper learning was taking place in this ecohydrology course. One student explicitly commented on TLA #2 and TLA #3 saying that together these TLAs helped put things in a practical context and "*that made it much easier to understand*". This contextual understanding is precisely the focal point called for by McClain et al. (2012) and can be seen as necessary for generating the next generation of functioning ecohydrologists.

Of course, as expected, there were criticisms with regard to the level of active learning involved in the course since this deviates from the tradition-styles normally encountered by students. According to one student, "*The structure felt somewhat unclear (during TLA #1) and there was a bit too much confusion*." This comment is likely motivated by the exploratory nature of the literature review used in TLA #1. Another student agreed and felt that more lecture-based teaching would be useful in the early stages (during TLA #1 and TLA #2). These comments touch on what can be a major roadblock for adopting more active learning approaches in our classrooms. Namely, this is the perceived difficulty by many teachers associated with incorporating active learning into courses. Such approaches can be perceived by students as, for example, unstructured relative to their lecture-based counterparts and may lead to low scores on course evaluations. This makes many teachers question if including active learning approaches are really worth the effort. Pathirana et al. (2012) note that "*Innovative [active] teaching is not synonymous with providing the students a comfort-zone in education. Indeed,* *students may feel somewhat uncomfortable, at least in the beginning, of the novel and unfamiliar approaches to education.*"

In our case study course, a student summed up this unstructured perception quite nicely by stating that in "*[TLA #1] we need more planned working [since] I prefer more planned working to know what I should do next.*" It is likely that the student identified the safety associated with planned lectures and uncertainty associated with open-ended questions (Lyon and Teutschbein, 2011) and experimentation. Still, it can be argued that it is exactly the creative thinking needed to solve such problems that we would like our students to obtain in an ecolohydrology course (McClain et al., 2012) or in a science-based Master's program in general. This serves to justify the potential added effort associated with developing and incorporating active learning methods in our teaching.

Although these student reflections are good indications that active teaching styles like those developed for this course are effective, we recognize that student feedback is not always the best indicator of this. Pathirana et al. (2012) caution that although "*student evaluations provide useful signals about such situations and can be invaluable mechanisms of feedback on how students feel [...] they do not necessarily provide good indications on how effective the education is.*"

4.4 Teacher reflections

The size of the course (6 students) was intentionally kept low to help with logistical planning during this initial offering of the course *Ecohydrology: A Mediterranean perspective*. As such, managing the high-level of active learning was rather efficient and effective. We do feel that this course structure, however, can be easily scaled up to the about 20 or so students one would expect in a second-year Master's level course dealing with ecohydrology. For example, considering ILO #3, students could easily be divided into several small groups to design and conduct different and/or complimentary experiments. The results of these different experiments could then be synthesized (either by the teachers or the students as an additional exercise) to build a broader sense of ecohydrology. To scale the course beyond about 20 students could potentially lead to logistic problems that can be common with any larger course. Such a large course size would also start to push the upper limit of what we would expect to see with regards to a cohort of students in a second-year Master's level course.

The number of students considered here may also make the student feedback less reliable due to a small population size. While this is a potential shortcoming to this current study, the small course size, in our opinion, helped create a fair amount of candor between students and teachers. As such, we tend to lend credibility to the students' reflections while being aware of the potential for bias (e.g. Pathirana et al., 2012) with regards to evaluating education. Further, we have not assessed student learning in the course using any examination-based assessment (see Supplement) due to the problems associate with such traditional assessment methods in problem-based learning environments (Lyon and Teutschbein, 2011). As such, we present our own short self-reflection here with regards to student performance in this course relative to our collective experiences in other courses offering more traditional forms of learning.

With regards to student involvement in the course, the level of active learning used in the course considered in this case study created more enthusiasm in the classroom than we typically associate with traditional learning environments. This potentially reflects the feeling of ownership of the education expressed by the students and, in our opinion, likely facilitates self regulation of learning. From the teacher perspective, this generally higher level of enthusiasm also makes teaching more enjoyable in a general sense creating a feedback effect whereby the teachers can become more involved in the learning process. Further, by having students develop and design experiments it allowed the level of teacher-student discourse in the classroom to be elevated over more traditional learning environments thus placing teachers and students on a consistent level (i.e. everyone was a researcher in the class). This consistent level aided communication which we feel helped facilitate knowledge transfer since it fostered an environment where students were not afraid to ask questions and/or offer opinions. This self-reflection is consistent with the restuls from the study by Lyon and Teutschbein (2011) on the utility of problem-based learning in the classroom.

Counter to potential benefits, such an open environment might be scary or uncomfortable for some students. Still, such an atmosphere from the teachers' perspective is rather stimulating and appropriate in a second-year Master's level course. To help alleviate some student apprehension, one could consider more hybrid approaches that couple both active learning and lecture-based approaches. As such, teachers could start with more traditional forms of teaching and slowly transfer and incorporate an active learning environment across the span of a course. With respect to this current case study course, we fully anticipate such hybridization will occur in future offerings. This should help lessen students' reflections regarding a "lack of structure" over time as we further develop and improve upon this course.

5 Concluding remarks

We have intended this case study to help serve as a potential road map for designing and implementing ecohydrology courses with respect to existing hydrology programs. In our case study example, we target plant-water interactions and ecohydrology from a Mediterranean perspective. While this suited our needs, such focus is clearly not necessary as the general structure presented here could be adopted to any of the "spheres" within ecohydrology (McClain et al., 2012) or be developed to leverage off of any established or startup field sites. Independent of the details, any ecohydrology course will by nature likely tend towards cross-disciplinary and inter-disciplinary work that warrants the consideration of active learning approaches. From our case study, students clearly identified the utility of such approaches over their more traditional, lecture-based counterparts for achieving course goals. With respect to "how active is active enough" we saw that on the one hand things can never be active enough but on the other there is added value associated with additional "activeness" in our teaching.

This is a positive take home message for those of us faced with developing attractive and successful ecohydrology courses on potentially limited budgets and time.

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Table 1. The main goal and intended learning outcomes (ILOs) for the recently taught course *Ecohydrology: A Mediterranean perspective*.

Main goal	The main goal of the course was to explore central theories in ecohydrology and their connection to plant-water interactions and the water cycle in a semiarid environment.
ILO #1	Explain and differentiate the basic theories and current literature that forms the core of ecohydrology.
ILO #2	Synthesize relevant data and observations to provide an ecohydrological ramework to characterize a region and set up a hydrologic model.
ILO #3	Define, develop, and conduct field-based research experiments to test fundamental assumptions behind our state-of-the-science understanding of the interactions between the water cycle and vegetation.
ILO #4	Communicate via a written scientific reports and presentations how the previous three outcomes intersect for Mediterranean perspective using the Navarino Environmental Observatory (NEO) as an example.

Table 2. Selected central concepts of ecohydrology identified by students with regards to ILO #1 in the course *Ecohydrology: A Mediterranean perspective*.

ILO #1: What is ecohydrology?
Ecohydrology studies how ecosystems and hydrology mutually affect and feedback on each other.
Ecohydrology investigates interrelationships between biota and water raising questions about potential human impacts on water resources.
Spatiotemporal climate-soil-vegetation dynamics appear central to much ecohydrology research and many key concepts.
In the field of ecohydrology, different approaches (i.e. from the viewpoint of an ecologist or a hydrologist) can lead to different end results and interpretations.
Ecohydrology can be considered as a way to look deeper into the importance of the boundaries and integration between hydrology and landscape perspectives.
Ecohydrology is a field that should operate in a cross-disciplinary mode in order to transcend both ecology and hydrology.

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Table 3. The overarching hypothesis and several supporting questions developed and answered by students in the course *Ecohydrology: A Mediterranean perspective*.

Overarching hypothesis
Evapotranspiration from the more-managed sites (and open water site) are higher than the evapotranspiration from the less-managed sites.
Supporting questions
Is the surface/air temperature of the managed (irrigated) areas lower than the unmanaged areas?
Is the relative humidity over the managed areas higher than over the unmanaged areas?
Is the vapor pressure over the managed areas higher than over the unmanaged areas?
What varies more over the course of the day: relative humidity or vapor pressure?
Is the soil moisture higher in the managed areas than in the unmanaged areas?
Is out-going radiation (or albedo) higher from managed or unmanaged areas?
How are the characteristics of the drip-irrigated (intermediately managed) areas different from the sprinkler (highly managed) and non-irrigated (unmanaged) areas?
How will pan evaporation differ between the open water site (located in a fountain) and dry site (located in a parking lot)?

Fig. 1. Students conducting field measurements and gathering data relevant to carry out the experiment they designed while Dr. M. Todd Walter (center with hat) supervises in the course *Ecohydrology: A Mediterranean perspective*.

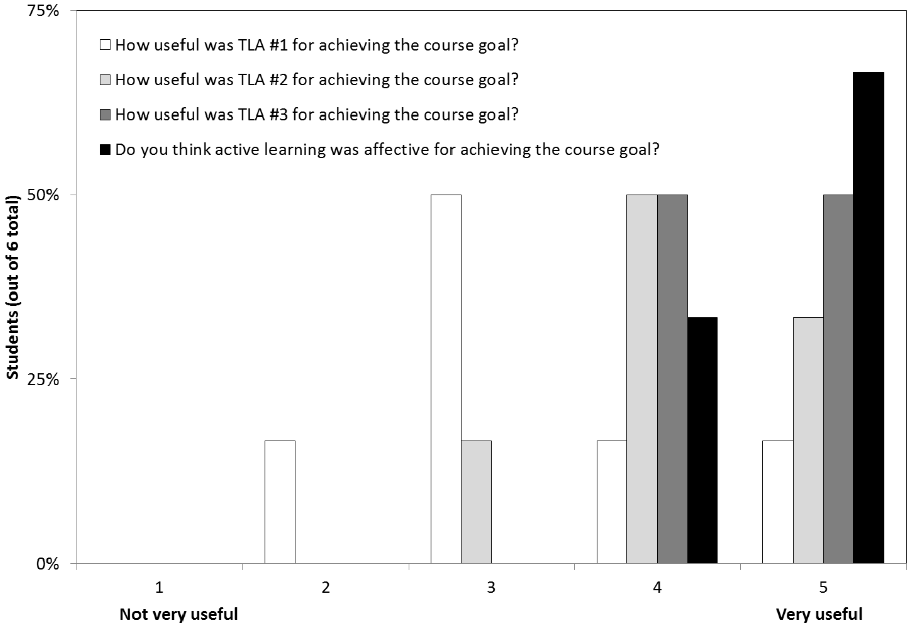

Fig. 2. Students' views regarding the utility of the active learning and various teaching and learning activities (TLAs) included in the course *Ecohydrology: A Mediterranean perspective*.