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# A Review of Water Resources Education in Geography Departments in the United States

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**Abstract:** Geographers have long played an important role in water resources scholarship; however, academic literature has not focused on the teaching contributions of geographers in this area. To address this gap, we cataloged courses taught and faculty interests for geography departments in the United States with a stated focus on water resources. We identified 129 departments with both courses and faculty having water resources expertise. The majority of water-related courses focused on climatology or climate change, suggesting that students are regularly provided opportunities to learn about water topics primarily through the lens of climatology and water resources. We also summarize a panel organized at the 2017 American Association of Geographers Annual Conference that focused on water resources curriculum in geography programs. The panel discussed curriculum and pedagogical approaches, concluding that a water resources course syllabi repository would be beneficial for creating new and refining existing water resources courses. The panel also recommended that faculty consider incorporating water resources topics into their general education classes to concurrently enhance student learning opportunities and positively impact recruitment and interest in geography programs. Additionally, online education represents a substantial change in higher education that presents new challenges and opportunities for geographers. We hope these data and the summary of the panel session stimulate greater discussions of curricular needs across all disciplines that offer water resource focused courses.

**Keywords:** *water resources, geographic education, curriculum development*

Water resource management is inexorably geographic (Tobin et al. 1989; Platt 1993; Wescoat 2005) because water exhibits spatial and temporal changes in availability, volume, and characteristics. Water is also a necessity, impacting how humans interact with both our natural and built environments (Vogel et al. 2015). Geographers contribute to the field of water resources through their ability to "synthesize the physical and social sciences" (Hedberg II 2017). This can be accomplished through teaching, research, and outreach. Geographers have a long history of engagement in key areas of research on water resources management (Tobin et al. 1989; Platt 1993; Lant 1998; Wescoat 2005; Agnew 2011). Wescoat (2005) provides perhaps the most thorough discussion of subfields in the geographic approaches to water. These include "hydrologic sciences, water management, water quality, law, and hazards" (Wescoat 2005, p. 283). Disaggregated, this discussion includes demand management, community planning, transboundary water allocations, social justice including exposition of indigenous rights, water's role in "gendered responsibilities" (Sultana 2015), climatic effects, water use monitoring via direct and remotely sensed technologies, water quality and study of pollutant dispersal, the water-energy nexus, and geomorphic effects. The fungible nature of water means research within these topical areas is evaluated at local, regional, and international scales.

The subfields of water resource management span the physical and social sciences, demonstrating the necessity of a broad curriculum. Tobin (2009)

stated, "we need a comprehensive, inclusive approach." The courses covering these topics should be transdisciplinary. Stentoft (2017) defines transdisciplinary as "the construction of new knowledge synthesized from differing disciplinary epistemologies into a new whole." In the higher education arena, critical reflection on water resources curriculum in geography departments has received scant attention. As a result, identification of opportunities to strengthen water resources curriculum in geography programs is limited.

To address the role geography departments play in educating and training future water resources professionals, we systematically reviewed the 2016-2017 Association of American Geographers (now American Association of Geographers (AAG)) Guide to Geography Programs (AAG GGP) to identify degree options, course offerings, and stated faculty foci. We also report on a water resources panel discussion at the 2017 AAG Annual Meeting to discuss curriculum issues confronting geographers teaching water resources courses. We conclude with a discussion of existing strengths, challenges, and opportunities for geography departments to strengthen contributions to water resources scholarship.

## Research Motivation and Origins

This project began as a survey of how many programs, faculty, and courses focus on water resources in geography departments in the United States (Chaney et al. 2015) and was influenced by work on natural hazards education in North American geography programs by Cross (2000). The original survey was based primarily on the 2013-2014 AAG GGP section on departmental specialties which was inspected to identify departments that indicated a focus on water resources. Departmental websites of the identified programs were subsequently reviewed to identify water courses and faculty. The survey and initial website review focused on three fundamental questions: 1) how many geography programs list water resources among their specialties?; 2) how many of their faculty members list water resources among their teaching and research interests?; and 3) how many course offerings focus specifically on water resources management?

The initial survey of geography departments demonstrated a strong focus on water resources; it also revealed the difficulty in documenting geography's influence in this interdisciplinary field (Vincent et al. 2016). It was also clear that the boundaries of water resources and ancillary fields such as climate, fisheries, and geomorphology are difficult to define. As a result, a follow-up call was placed to AAG Water Resources Specialty Group (WRSG) members for comments and input. We discovered some programs were omitted from our review because their interdisciplinary nature meant they were not specifically within the domain of a geography department or the department did not submit information to the AAG Guide (AAG 2014) for the 2013-2014 year. Regardless of the reason, the data gaps were identified, which led to a follow-up investigation.

## 2016-2017 Survey of Water Resources in U.S. Geography Departments

We inspected the 2016-2017 AAG GGP (AAG 2017) departmental specialties section to identify departments that indicated a focus on water resources (limited to programs in the United States). We also inspected institution membership data for the Universities Council on Water Resources (UCOWR) and the National Institutes of Water Resources (NIWR) which identified eight additional geography departments with water courses and geography faculty indicating a research interest in water. Of the departments with a stated water resources focus, departmental websites were analyzed for additional information such as faculty and course listings.

To address limitations from the preliminary review, we used a broad set of search terms including the critical dimensions of water management in geography identified by Wescoat (2005). The search terms were: water, hydro, river, climat, wetland, watershed, fluvial, marine, and ocean. These terms were used to search department websites to identify faculty with water foci and to search course catalogs. One hundred forty-two of the 192 (74%) U.S. departments identified water resources as a program specialty (Figure 1), with 103 of these departments offering a M.S. degree and 58 offering a Ph.D.

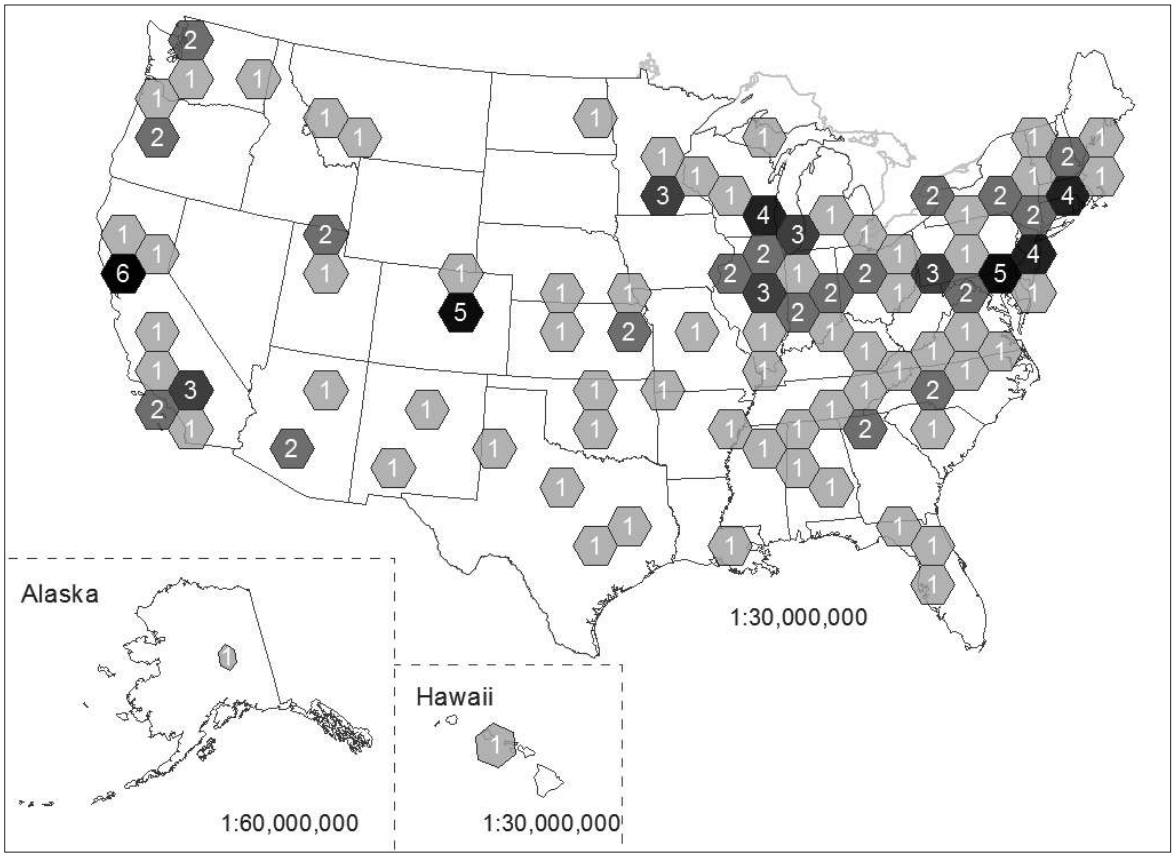


**Figure 1.** Geographic distribution of geography programs in the United States with a stated water resources foci (Data sources: 2016-2017 AAG GGP, UCOWR, and NIWR member lists). The number indicates the number of schools in that region.

Of the 142 programs with a stated foci on water, 135 programs (95.1%) have faculty who list research interests related to water (Figure 2) (Table 1). Additionally, 129 of these programs (90.8%) have both faculty who list water resources as a research interest and teach water courses with a geography prefix; it should be noted programs that do not appear to offer water courses in geography may offer them under a different prefix. There were 129 programs (90.8%) that offered at least one course that focused on water and 83 departments with three or more course offerings containing these terms (Figure 2). Of departments offering courses with these titles, the mean number of water courses is 4.12.

In total, we identified 532 water-related courses offered through geography programs, of which more than half (n=285) were climatology or climate change focused (Figure 3). To further evaluate the topical focus of identified water courses we excluded climate courses and categorized the remaining water resources courses into the categories of water resources (which broadly includes water resource management and governance), hydrology, fluvial geomorphology, oceans and marine, rivers, wetlands and watersheds, groundwater, and other (Figures 4 and 5). We also observed that water resources courses account for the most common water-specific courses taught in geography programs. These courses include both physical and human elements of water resources, which provide students an overview of the multifaceted nature of water resource issues. These courses may also introduce students to water law, natural resources economics, hydrology, the concept of water as a human right, and ecological aspects of water resources. Other more physical geography focused topics, such as hydrology, fluvial geomorphology, and groundwater are taught with less frequency as standalone courses

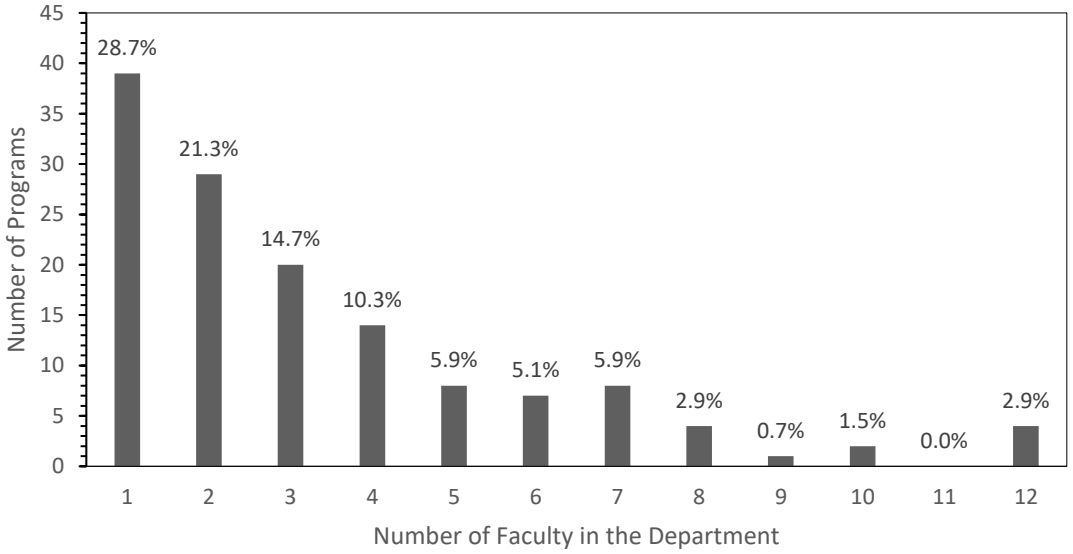


**Figure 2.** Number of geography departments with a given number of faculty with a focus on water resources (n=135) (Data sources: 2016-2017 AAG GGP, UCOWR, and NIWR member lists).

**Table 1.** Water resources related fields of interest listed by faculty.

| Key Term Category | Faculty (count) |
|---|---|
| Climate change and impacts | 77 |
| Climatology | 177 |
| Coastal, marine, and oceans | 9 |
| Drought | 5 |
| Fluvial geomorphology | 43 |
| Groundwater | 4 |
| Hydrology and ecohydrology | 56 |
| Modeling, remote sensing, and GIS | 17 |
| Planning | 7 |
| Rivers, stream ecology, and stream restoration | 11 |
| Snow and alpine environments | 6 |
| Stream and watershed ecology | 14 |
| Water quality | 5 |
| Water resources and governance | 75 |
| Watershed management | 7 |

Note: Each faculty member's first research interest is listed. Many faculty list "water resources" as a somewhat generic term for their research interest which may be the reason some of the subsets seem under-represented in the count (n=513 total faculty).

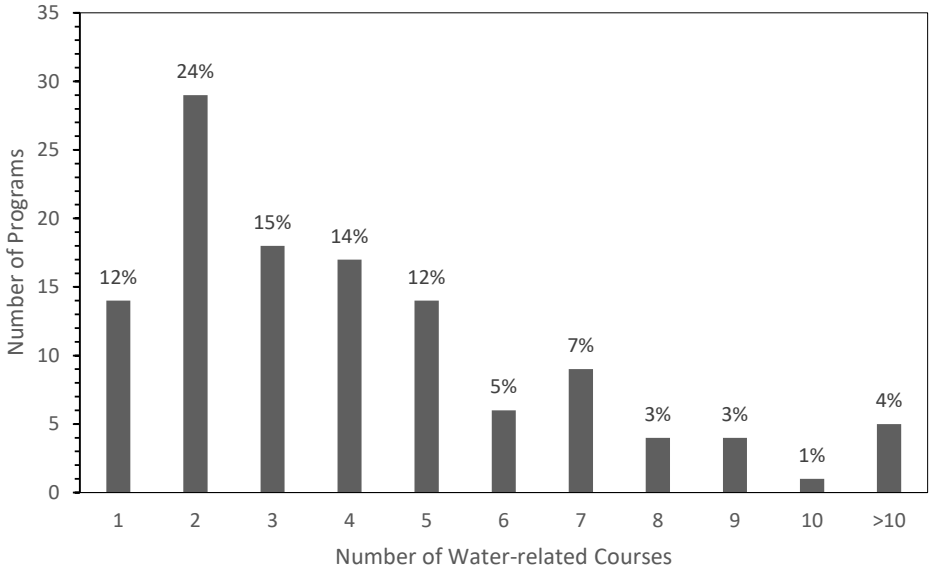


**Figure 3**. Summary of the number of water focused courses offered per geography department.

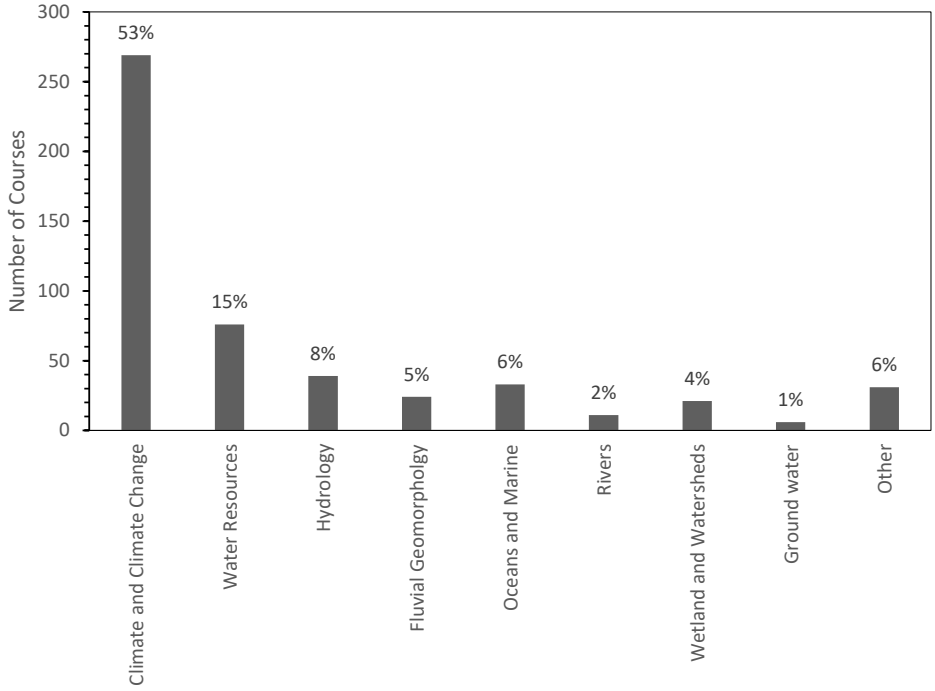


**Figure 4.** Water focused courses in geography departments.

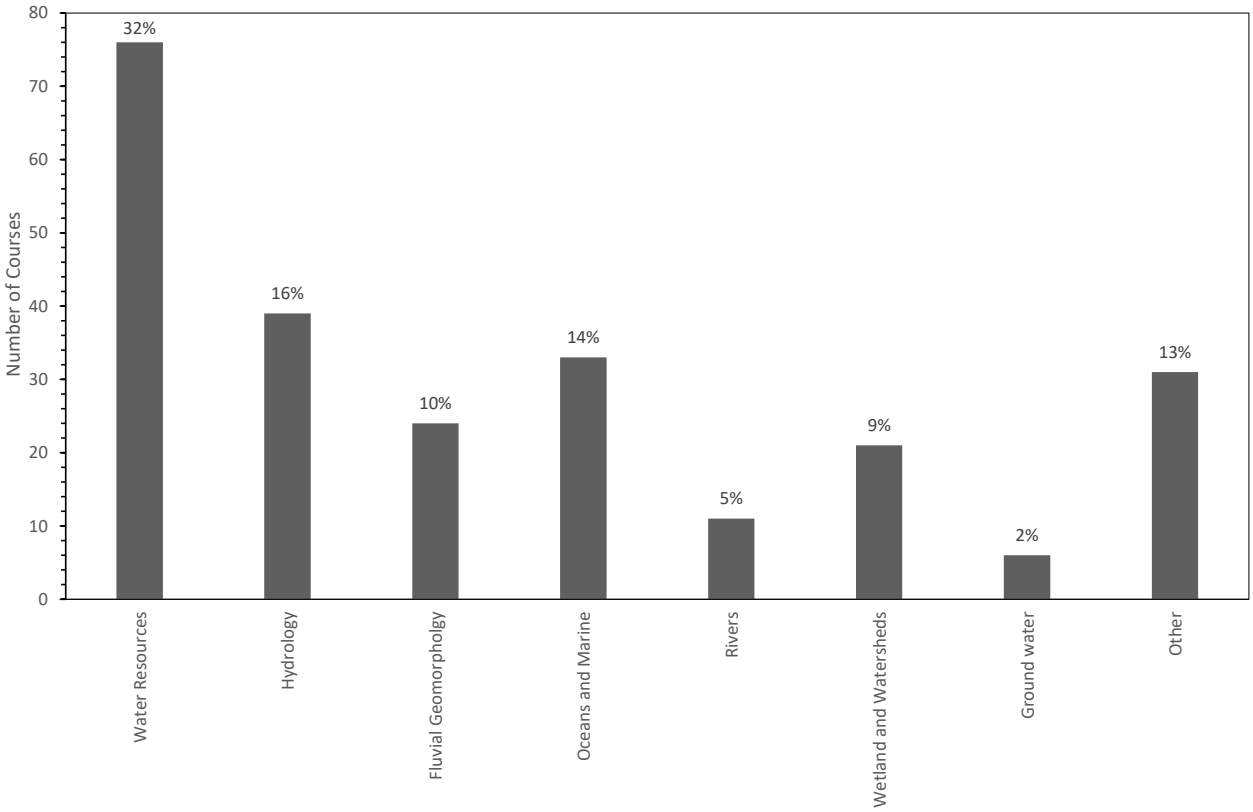


**Figure 5.** Water courses in geography programs excluding climate courses.

(n=69). Collectively, these results suggest that students are regularly provided opportunities to learn about water topics primarily through the lens of climatology and water resources.

## Panel on Water in Geography Programs

To further understand geography's role in water resources scholarship and teaching we organized a panel entitled "Water Resources in Higher Education" at the 2017 AAG Annual Conference in Boston, Massachusetts (Chaney and Pease 2017). The purpose of this panel was to discuss the current structure of geography programs across the United States as it relates to water resources, and to discuss types of technical information and skills that students need at both the undergraduate and graduate levels. The panel consisted of six tenured water resource professors in departments of geography, ranging from research-intensive universities to teaching-focused regional comprehensive universities. For the present paper we focus on the curriculum and course offering comments offered by the panel, as recorded by the notes of the panelists. The curriculum and course offering aspects of the panel discussion were semi-structured, guided by seven pre-scripted questions (Table 2). These questions were crafted based on the results of the analysis of the 2013-2014 AAG Guide to Programs. These questions were designed to solicit conversation about program structure, number of course offerings in water that may be integrated into a geography curriculum, and student recruitment.

### Curricular Discussions

The panel discussion initially focused on course syllabi, the importance and process of establishing water courses in general education courses, water resources course sequences, course prerequisites, and course content.

Sample syllabi were shared amongst the panelists and audience members. The need for a discipline-wide repository of syllabi was discussed. This elicited calls for contributions

**Table 2.** Questions asked in the panel on Water Resources in Higher Education at the 2017 AAG Annual Meeting.

| |
|---|
| 1. What major issues/topics related to water resources should we prepare students to address in the future? |
| 2. What general areas should be covered in a course titled "Water Resources" to provide students a good overview of the field? |
| 3. Should a program promoting itself as having a specialty in water resources actually offer a specific course titled "Water Resources" that provides students an overview of the field? |
| 4. Should a program promoting itself as having a specialty in water resources offer more than one course in the field? If so, how many? |
| 5. Should a program attempt to offer a specific degree (major/minor) or certificate option in water resources? What should it focus on, and what courses should be included? |
| 6. Should geography departments look to partner with other departments to develop "interdisciplinary" degree/certificate options? |
| 7. What major challenges might a department face in attempting to initiate or expand a concentration (degree/certificate) in water resources? |

of syllabi and instructional materials using the AAG WRSG Knowledge Community. The WRSG is now collecting contributions of syllabi from all members and is making these available on the WRSG website so members can see what others are covering in their courses. It can also increase collaboration among faculty at different universities teaching similar courses.

The need to represent water resource issues in general education courses was another key topic discussed. Several panelists noted that incoming university freshman are increasingly aware that freshwater issues are important, but lack context and an understanding of the scientific aspects of these issues. The panelists agreed that introducing students to the scientific and engineering aspects of water issues, through a Physical Geography or World Regional Geography course for example, is critical for recruiting students for more advanced water focused classes. Furthermore, several panelists and audience members stated their universities have developed and implemented a general education course focused on water. These general education courses provide students from a variety of programs access to geographic and water resources education and these courses provide recruiting opportunities for water resource and geography programs. It was noted that perhaps this may be the greatest area for growth among geography programs as they relate to water. Increasing general education offerings provides more exposure to issues of water management and sustainability, a fast-growing field (Smith 2009; Cohen 2012; Huggett 2017) in which geography plays a key role (Clark 2009). Increasing general education offerings can be done while also increasing student credit hours for departments, which near universally are being evaluated by this metric (Frazier and Wikle 2017).

Panelists then discussed their experiences establishing logical sequences of water courses. One of the discussion points focused on prerequisites, particularly for hydrology. A modicum of mathematical aptitude is needed for even the most basic hydrology calculations; however, requiring specific math courses can stymie enrollment. Whether such a prerequisite is appropriate is a function of the course level, learning objectives, and specific material covered. Development of analytical thinking and analysis skills was also identified as an important skill for geography students because of job opportunities in state government and industry where a background in hydrology and related subject matter was critical for employment (Rooney et al. 2006; Solem et al. 2008; Solem et al. 2013).

Discussion also addressed the extent to which instructors should integrate law, natural resource economics, social sciences with a focus on social justice and gender equality, and biology into

water resources courses. Each of these subject areas merit integration into a complete water curriculum. In particular, social justice issues have been underrepresented in geography water curriculum (Zeitoun et al. 2014), yet are topics within the normal domain of geographic inquiry. However, determining how to integrate these into a broader geography degree is less clear. This ubiquitous 'depth versus breadth' discussion is nonetheless valuable. Most panelists stated a desire to integrate basic environmental law into a water curriculum. It was noted that a basic understanding of civics and administrative processes is part of an undergraduate education. Adding the specificity of the Endangered Species Act, the National Environmental Policy Act, or the Clean Water Act provides needed content to students and helps their professional development. Similarly, providing students with a basic understanding of non-market economics was deemed advantageous.

**Pedagogical Approaches**

The panel discussion also addressed the challenges and opportunities of using an active-learning based pedagogy in water courses. Utilizing active learning approaches and realistic simulations has received significant attention in pedagogical literature (Smith and Boyer 1996; Halvorson and Wescoat 2002; Fink 2003; Asal and Blake 2006; Baranowski 2006; Pawson et al. 2006; Porter 2012; Schnurr et al. 2014; Lant et al. 2016; Chaney and Doukopoulos 2018; Pease et al. 2018). Active learning simulations and projects can be particularly effective for research issues involving multiple actors (Brown and King 2000; Halvorson and Wescoat 2002; Crossley-Frolick 2010; Kirshner et al. 2011; Schnurr et al. 2014) and highly technical subject matter (Baranowski 2006; Krain and Shadle 2006). Data suggest such simulations and other direct learning structures help students better understand the theories, organizations, and processes involved (Shellman and Turan 2006; Hope 2009).

Panelists indicated water resource management courses seem particularly well suited for the integration of active learning assignments since these courses prioritize competencies over content (Stentoft 2017) and water management requires integration of a variety of issues and stakeholders. Here we define active learning as activities that "engage students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert" (Freeman et al. 2014). In their review of interdisciplinary proposals for graduate programs, Borrego and Newswander (2010) recognized "team-based collaboration is the norm in engineering and science." Stentoft (2017) provides a critique of problem based learning for transdisciplinary problems and suggests it can be effective, but crossing disciplines is in itself not pedagogical scaffolding. Mansilla (2010) proposes four interrelated cognitive processes involved in interdisciplinary learning: "establishing purpose; weighing disciplinary insights; building leveraging integrations; and maintaining a critical stance." Each of these are traits that can be appreciated by water managers. No member of the panel indicated they have conducted formal summative assessment of active learning outcomes against direct instruction methods. The lack of rigorous formative assessment of these active-based exercises is an issue acknowledged by several who have conducted research in this area (Borrego and Newswander 2010; Domik and Fischer 2010), and clearly requires further research.

**Panel Recommendations**

The panel discussion illustrated several key points that warrant additional discussion and investigation. First, the utility of a water resources course syllabi repository was recognized as a tool for creating new and refining existing water resources courses. The WRSG has initiated development of this repository. Second, the panel recommended that faculty consider incorporating water resources topics into their general education classes. Panelists observed that water-related topics frequently resonate well with students and provide opportunity to attract students to the geography discipline. Third, developing course sequences for water resource topics needs to balance math and science pre-requisites with course level and student preparedness. Water resources courses in geography programs are also well suited to incorporate social, legal, and other aspects of water resource issues in an interdisciplinary framework. Water resources courses seem well suited to active learning exercises that may benefit student learning.

While the panelists had limited experience using active learning exercises in their classes, we are aware of others who have applied these techniques. Further investigation is needed to explore barriers and challenges that faculty, at different career stages, face when implementing active learning exercises. We suggest that faculty developing a new water resources course, or refining an existing course, consider some of these recommendations as well as convey successes and challenges to the broader water resources community.

## Discussion

The AAG GGP is a valuable source of information about geography programs in the U.S. and abroad. This Guide may serve as a resource for current and future students to learn about programs and to identify departments of interest. Our research presented here, focused on water resources and identified several opportunities for those using and contributing to this Guide. The content of the Guide is updated by individual departments and as a result, information may vary from edition to edition. We identified more departments with a focus on water resources in the 2016-2017 edition than the 2013-2014 edition. We also observed that the AAG Guide encompassed nearly all of the geography departments with UCOWR and NIWR institutional membership.

Analysis of course offerings also provides insight into water-related material taught through geography departments. A majority of the water-related courses we identified were couched in the context of climate and with water resources as the second most common context. Of the 45 programs offering two or less water-related courses, 52 of the 73 courses (71.2%) were climate focused. The emphasis on climate-related courses is mirrored by faculty interest in climate with 254 of 513 identified geography faculty (49.5%) indicating that climate is a research interest. Collectively, this suggests a strong teaching emphasis on climate and climate-related issues, including water resources, which is a timely and critical area of research and education. Topical areas such as groundwater, water quality, and watershed management courses are less frequently taught through geography programs and are examples of future course work that may be of interest to students and important for their career preparation.

These survey results have several limitations that should be acknowledged. Potential sources of error include departments not updating their listing in the AAG Guide, departments not listed in the Guide due to failure to submit their information to AAG, and departments not listed due to some other type of oversight, which likely applies to some ‘interdisciplinary’ programs. The issue of programs not submitting data to the AAG is a perpetual one. Interestingly, in the 2016-2017 Guide, 46 programs self-identifying a focus on water were not included in the 2013-2014 Guide; this coincides with a concerted effort by the AAG to encourage programs to provide these data for the Guide. It is also possible the increase is the result of some programs adding a focus on water resources with new faculty hires during this time. There is also the possibility water-centric courses were omitted because of our search criteria. For example, courses entitled Arid Lands were excluded but it is possible these courses have water or land use as a central theme. The same could be said for regional courses such as the Geography of the Southwest or the Geography of the Great Lakes Region.

Funding challenges and budget shortfalls may generate a greater need for additional student credit hours to justify funding and staffing (Frasier and Wikle 2017). Anecdotally, competition for student credit hours results in the construction of counterproductive academic “walls” between disciplines (Evans and Randalls 2008; Nation 2008). Some of these struggles over credit hours may directly threaten geography programs because some interdisciplinary programs encroach on the traditional domain of geography (Frazier and Wikle 2017; Hedberg II et al. 2017). Vincent et al. (2016) referred to staffing from geographers as the “glue” holding together interdisciplinary programs. Current funding and accounting models threaten to reduce collaboration, undermining interdisciplinary programs like water resources (Smith 2009). University-level accounting models will determine how individual programs are affected and input from geography faculty may help guide the development and assessment of those models.

This unfortunate reality creates challenges but also opportunities for geography departments. As discussed by the Water Resources in Higher Education panel at the 2017 AAG, general education classes represent an opportunity for recruiting students and focusing these classes towards "hot button" natural resource issues may include topics such as access to freshwater and climate change (Earl et al. 2009). Cross-listing courses and developing general education curricula in which geography classes are required also contributes to student education and may increase enrollment. Despite a more competitive enrollment environment, there remain opportunities for geography departments to integrate with interdisciplinary degree programs, increase student recruitment, and provide greater visibility to students in other programs (Henderson 2014).

### Online Education

Online education represents one of the most substantial changes to higher education in the last 50 years (Madge and O'Connor 2004; Kentnor 2015). Here, we are including hybrid courses, those that blend traditional face-to-face and online instruction. Online education opportunities open new possibilities in access, but also carry unique challenges. Debates over the appropriateness and format of courses, i.e., synchronous versus asynchronous formats, are ongoing and should continue (Johnson 2006; Giesbers et al. 2014). Massive Open Online Courses (MOOCs) are a relatively new development in online learning. At the time of this writing, a search of Class Central (2018), a clearinghouse of available MOOCs, indicated 27 courses offered in English with water in the course title and more than 160 courses included water as a course topic. Of these, 37 courses were identified as specifically relating to water management in the range that geographers work (Table 3). We offer no comment on the content of these courses. We include this search of courses because the proliferation of water-focused courses shows its salience and the growing public interest in water resource management issues. Numerous MOOCs are moving to a tiered approach in which the materials are available for free, but a "premium" option is available in which assignments are graded and either university credit or a certificate of completion is available. The impacts of MOOCs on higher education and student learning remain uncertain (Waldrop 2013; Dennis 2017).

## Conclusions

Geography provides students and academics opportunities to integrate physical, human, and GIScience research methods to advance understanding of water resource issues from a variety of perspectives. More than half of the geography departments in the United States indicate faculty expertise and program curriculum that nominally support water resources education. Changes to university education and funding models

**Table 3.** MOOC offerings in February 2018. These data are derived from class-central.com.

| Course Type | # of Courses | # Available for Credit/Certificate | Other |
|---|---|---|---|
| Water resource management | 15 | 6 | Multiple courses can be taken to earn an additional certificate. |
| Hydrology or fluvial geomorphology | 2 | 1 | |
| Water-focused climate courses | 8 | 3 | |
| Food and energy nexus | 7 | 5 | |
| Water-focused health and sanitation | 8 | 6 | Includes several classes that appear to have recently concluded. |

threaten the status-quo, encouraging emphasis on large undergraduate courses that generate higher quantities of student credit hours. Geography departments are well-positioned to provide teaching and research opportunities for students through general education courses, specific water resource management and hydrology courses, and contributions to interdisciplinary programs. That said, geography departments represent one piece of water education, and integration with other disciplines is necessary to ensure students receive education on as many facets of water management as possible. We hope that this article spurs further conversation of geography curriculum and its integration in interdisciplinary programs for students interested in pursuing water resource careers. We recognize the need to develop more formal and rigorous protocols for assessment of curricula. Finally, we see a need to have a broader discussion of online education and its role in water resources.

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## References

Agnew, J. 2011. Waterpower: Politics and the geography of water provision. *Annals of the Association of American Geographers* 101(3): 463-476.

American Association of Geographers (AAG). 2017. 2016-2017 Guide to Geography Programs in the Americas. Available at: http://www.aag.org/galleries/guide/20162017_Guide_to_Geography_Programs_in_the_Americas.pdf. Accessed August 14, 2019.

Asal, V. and E. Blake. 2006. Creating simulations for political science education. *Journal of Political Science Education* 2(1): 1-18.

Association of American Geographers (AAG). 2014. 2013-2014 Guide to Geography Programs in the Americas. Available at: http://www.aag.org/galleries/publications-files/20132014_Guide_to_Geography_Programs_in_the_Americas_72414.pdf. Accessed August 14, 2019.

Baranowski, M. 2006. Single session simulations: The effectiveness of short congressional simulations in introductory American government classes. *Journal of Political Science Education* 2(1): 33- 49.

Borrego, M. and L. Newswander. 2010. Definitions of interdisciplinary research, toward graduate-level interdisciplinary learning outcomes. *The Review of Higher Education* 34(1): 61-84.

Brown, S.W. and F.B. King. 2000. Constructivist pedagogy and how we learn: Educational psychology meets international studies. *International Studies Perspectives* 1(3): 245-254.

Chaney, P.L. and L. Doukopoulos. 2018. An active learning exercise on sustainability and the water footprint of food: The dinner party menu challenge. *The Geography Teacher* 15(4): 173-184.

Chaney, P.L. and M. Pease. 2017. Water resources

in higher education. American Association of Geographers Annual Conference, April 5 – April 9, 2017, Boston, MA.

Chaney, P.L., R. Greene, and A. Ware. 2015. A survey of water resources programs in U.S. geography departments. 2015 Annual Meeting of the Association of American Geographers, Chicago, IL.

Clark, G.E. 2009. Academic geography for sustainability. *Environmental Science and Policy for Sustainable Development* 51(3): 5-6.

Class Central. 2018. "MOOC Search". Available at: https://www.class-central.com/search?q=water. Accessed August 14, 2019.

Cohen, S. 2012. The growing field of sustainability studies. *The Huffington Post*, February 13, 2012.

Cross, J.A. 2000. Hazards courses in North American geography programs. *Environmental Hazards* 2: 77-86.

Crossley-Frolick, K.A. 2010. Beyond model UN: Simulating multi-level, multi-actor diplomacy using the millennium development goals. *International Studies Perspectives* 11(2): 184-201.

Dennis, M.J. 2017. Let's take another look at MOOCs. *Enrollment Management Report* 21: 1-3.

Domik, G. and G. Fischer. 2010. Coping with complex real-world problems: Strategies for developing the competency of transdisciplinary collaboration. *IFIP Advances in Information and Communication Technology* 324: 90-101.

Earl, R.A., E.J. Montalvo, A.R. Ross, and E. Hefty. 2009. Environmental science education programs: Opportunities for geographers. *Journal of Geography* 108(6): 259-268.

Evans, J. and S. Randalls. 2008. Geography and paratactical interdisciplinarity: Views from the ESRC–NERC PhD Studentship Programme. *Geoforum* 39(2): 581-592.

Fink, L.D. 2003. *Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses* (2nd edition). Jossey-Bass, San Francisco, CA.

Frazier, A.E. and T.A. Wikle. 2017. Renaming and rebranding within U.S. and Canadian geography departments, 1990-2014. *The Professional Geographer* 69(1): 12-21.

Freeman, S., S.L. Eddy, M. McDonough, M.K. Smith, N. Okoroafor, H. Jordt, and M.P. Wenderoth. 2014. Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences* 111(23): 8410-8415.

Giesbers, B., B. Rienties, D. Tempelaar, and W. Gijselaers. 2014. A dynamic analysis of the interplay between asynchronous and synchronous communication in online learning: The impact of motivation. *Journal of Computer Assisted Learning* 30(1): 30-50.

Halvorson, S.J. and J. Wescoat. 2002. Problem-based inquiry on world water problems in large undergraduate classes. *Journal of Geography* 101(3): 91-102.

Hedberg II, R.C., A. Hesse, D. Baldwin, J. Bernhardt, D.P. Retchless, and J.E. Shinn. 2017. Preparing geographers for interdisciplinary research: Graduate training at the interface of the natural and social sciences. *The Professional Geographer* 69(1): 107-116.

Henderson, K.G. 2014. The Impact of interdisciplinary environmental degree programs in the United States. *Middle States Geographer* 47: 9-16.

Hope, M. 2009. The importance of direct experience: A philosophical defense of fieldwork in human geography. *Journal of Geography in Higher Education* 33(2): 169-182.

Huggett, S. 2017. Sustainability Science Continues to Grow, Per Updated Analysis. Available at: https://www.elsevier.com/connect/sustainability-science-continues-to-grow-per-updated-analysis. Accessed August 14, 2019.

Johnson, G.M. 2006. Synchronous and asynchronous text-based CMC in educational contexts: A review of recent research. *TechTrends* 50(4): 46-53.

Kentnor, H.E. 2015. Distance education and the evolution of online learning in the United States. *Curriculum and Teaching Dialogue* 17(1): 21-34.

Kirschner, F., F. Paas, P.A. Kirschner, and J. Janssen. 2011. Differential effects of problem-solving demands on individual and collaborative learning outcomes. *Learning and Instruction* 21: 587-599.

Krain, M. and C.J. Shadle. 2006. Starving for knowledge: An active learning approach to teaching about world hunger. *International Studies Perspectives* 7(1): 51-66.

Lant, C., B. Perez-Lapena, W. Xiong, S. Kraft, R. Kowalchuk, and M. Blair. 2016. Environmental systems simulations for carbon, energy, nitrogen, water, and watersheds: Design principles and pilot testing. *Journal of Geoscience Education* 64: 115-124.

Lant, C.L. 1998. The changing nature of water management and its reflection in the academic literature. *Water Resources Update* 110: 18-22.

Madge, C. and H. O'Connor. 2004. Online methods

in geography educational research. *Journal of Geography in Higher Education* 28(1): 143-152.

Mansilla, V.B. 2010. Learning to synthesize: The development of interdisciplinary understanding. In: *The Oxford Handbook of Interdisciplinarity*, R. Frodeman, J.T. Klein, and C. Mitcham (Eds.). Oxford University Press, Oxford, UK, pp. 288-306.

Nation, M.L. 2008. Project-based learning for sustainable development. *Journal of Geography* 107(3): 102-111.

Pawson, E., E. Fournier, M. Haigh, O. Muniz, J. Trafford, and S. Vajoczki. 2006. Problem-based learning in geography: Towards a critical assessment of its purposes, benefits and risks, *Journal of Geography in Higher Education* 30(1): 103-116.

Pease, M., B. Pérez-Lapeña, and C. Lant. 2018. Energy and water resource simulations for U.S. undergraduates. *Journal of Geography in Higher Education* Issue vol, TBD.

Platt, R. 1993. Geographers and water resource policy. In: *Water Resources Administration in the United States*, M. Reuss (Ed.). East Lansing, Michigan State University and American Water Resources Association, pp. 36-54.

Porter, J. 2012. Lessons from the Dust Bowl: Human-environment education on the Great Plains. *Journal of Geography* 111(4): 127-136.

Rooney, P., P. Kneale, B. Gambini, A. Keiffer, B. Vandrasek, and S. Gedye. 2006. Variations in international understandings of employability for geography. *Journal of Geography in Higher Education* 30(1): 133-145.

Schnurr, M.A., E.M. De Santo, and A.D. Green. 2014. What do students learn from a role-play simulation of an international negotiation? *Journal of Geography in Higher Education* 38(3): 401-414.

Shellman, S. and K. Turan. 2006. Do simulations enhance student learning? An empirical evaluation of an IR simulation. *Journal of Political Science Education* 2(1): 19-32.

Smith, E.T. and M.A. Boyer. 1996. Designing in-class simulations. *Political Science and Politics* 29(4): 690-694.

Smith, W.J. 2009. Problem-centered research for the exploration of sustainability. *Journal of Contemporary Water Research and Education* 142: 76-82.

Solem, M., I. Cheung, and M.B. Schlemper. 2008. Skills in professional geography: An assessment of workforce needs and expectations. *The Professional Geographer* 60(3): 356-373.

Solem, M., A. Kollasch, and J. Lee. 2013. Career goals, pathways and competencies of geography graduate students in the USA. *Journal of Geography in Higher Education* 37(1): 92-116.

Stentoft, D. 2017. From saying to doing interdisciplinary learning: Is problem-based learning the answer? *Active Learning in Higher Education* 18(1): 51-61.

Sultana, F. 2015. Rethinking community and participation in water governance. In: *The Routledge Handbook of Gender and Development*, A. Coles, L. Gray, and J. Momsen (Eds.). Routledge, London, UK, pp. 261-272.

Tobin, G.A. 2009. Water promises: Much ado about nothing—As profitless as water in a sieve? *Journal of Contemporary Water Research and Education* 142: 1-3.

Tobin, G.A., D.D. Baumann, J.E. Damron, J.L. Emel, K.K. Hirschboeck, O.P. Matthews, and B.E. Montz. 1989. Water resources. In: *Geography in America*, G. Gaile and C. Willmott (Eds.). Merrill, Columbus, OH, pp. 113-140.

Vincent, S., J.T. Roberts, and S. Mulkey. 2016. Interdisciplinary environmental and sustainability education: Islands of progress in a sea of dysfunction. *Journal of Environmental Studies and Sciences* 6(2): 418-424.

Vogel, R.M., U. Lall, X. Cai, B. Rajagopalan, P.K. Weiskel, R.P. Hooper, and N.C. Matalas. 2015. Hydrology: The interdisciplinary science of water. *Water Resources Research* 51(6): 4409-4430.

Wescoat, J. 2005. Water resources. In: *Geography in America at the Dawn of the 21st Century*, G.L. Gaile and C.J. Willmott (Eds.). Oxford University Press, New York, NY, pp. 283-301.

Zeitoun, M., J. Warner, N. Mirumachi, N. Matthews, K. McLaughlin, M. Woodhouse, A. Cascão, and T.J.A. Allan. 2014. Transboundary water justice: An exploration of social justice and the analysis of international transboundary water interaction. *Water Policy* 165: 174-193.