On the interdisciplinary nature of water-related programs in American public universities

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Abstract. This paper presents a research on the interdisciplinary nature of 167 water-related programs in 46 selected American public universities. Using keyword coding and Classification method, and the results show that water-related disciplines largely focus on environment, natural resources, engineering, ocean and agricultural studies, which are all applied disciplines. Moreover, water-related disciplines lay great emphasis on the interdisciplinary research and research platforms construction with the research fields of environment, natural resources and agricultural.

1. Introduction
As the material basis for human survival, water has linked thousands of things in nature, and water-related issues are major livelihood issues. In recent years, water-related problems have become more and more complex, and also more difficult to solve. Problems such as water disasters, water shortages, water ecological damage and water pollution occurs everywhere around the world. It’s essential for a country to develop education and research programs focusing on water issues. Since the establishment of the People’s Republic of China, the development of water-related research and education in China has made great achievements over the past 60 years. Meanwhile, there are still a few problems—the universities establishing water-related disciplines are mainly technological universities, and the interactions and collaborations between water-related disciplines and other disciplines are insufficient. Facing the complexity and flexibility of water-related problems, it is important for China to cultivate high quality water-related interdisciplinary programs, as well as build capacity in both water education and water research, in order to give better solutions to contemporary water problems.

University-based water-related interdisciplinary programs play a main and important role in water research. American universities (especially public universities) are the leaders in water-related research [1]. Among the world’s top 11 institutions which published the most research papers in the field of water resource management from 1990 to 2012, 8 institutions were from the United States, and four of them were American public universities, namely, Texas A & M University, University of Arizona, New Mexico State University, and Colorado State University [2]. Therefore, American public universities are a perfect source for the study of water-related programs. We selected a group of 46 American public universities as the sample. By analyzing the water-related degree programs as well as the academic departments and colleges which host those programs in American public universities, we aimed to explore the interdisciplinary nature in water-related programs, and find the patterns of the interaction between both water-related and unrelated disciplines.
2. Definition of Water-related Interdisciplinary

Nowadays, the development of water-related disciplines is no longer limited to “pure” water disciplines, but widely interacts and integrates with other disciplines, resulting in a number of emerging water-related subjects or water-related research fields, such as water economy, water culture, water education and so on [3][4]. According to the classification standards for academic programs and water-related research, we define the water-related interdisciplinary as academic programs or degree programs focusing on the education and research of both water-related problems and direct water problems. Non-degree programs are not included in our study.

3. Sample and Method

3.1 Selecting Research Samples

The research samples were selected from member universities of National Institutes for Water Resources (NIWR). NIWR consists of nationwide water resources institutes based at 54 public universities in the United States [3]. Among these universities, 8 universities without water-related interdisciplinary degree programs were removed. Finally, we selected 46 American public universities as the sample (see Table 1). These public universities belong to 44 different states and major territories. A collection of outstanding public universities are included in our sample, which covers University of California at Davis, Georgia Institute of Technology, University of Minnesota at Twin Cities, Purdue University, etc. Through a thorough search in the universities’ official websites, we eventually identified 167 water-related degree programs offered by 46 universities. Each targeted university offers 3.6 water-related degree programs on average, indicating that the sample is ideal for our research since the universities we selected have strong roots in water-related research.

Table 1. 46 American public universities list (in alphabetical order).

| Colorado State University | University of Alabama at Huntsville | University of Missouri-Columbia |
|---------------------------|--------------------------------------|---------------------------------|
| Cornell University        | University of Alaska Fairbanks       | University of Nebraska-Lincoln  |
| Georgia Institute of Technology | University of Arizona             | University of Nevada, Reno     |
| Iowa State University     | University of Arkansas               | University of New Hampshire    |
| Mississippi State University | University of California-Davis    | University of Rhode Island     |
| Montana State University Bozeman | University of California-Riverside | University of South Carolina   |
| New Mexico State University | University of Connecticut           | University of Tennessee, Knoxville |
| North Dakota State University | University of Delaware             | University of the District of Columbia |
| Ohio State University     | University of Florida               | University of Vermont           |
| Oklahoma State University | University of Idaho                 | University of Wisconsin-Madison |
| Oregon State University   | University of Kentucky              | University of Wyoming           |
| Pennsylvania State University | University of Maryland, College Park | Utah State University          |
| Purdue University         | University of Massachusetts, Amherst | Virginia Polytechnic Institute and State University |
| Rutgers, New Jersey State University | University of Minnesota Crookston Campus | Washington State University |
| South Dakota State University | University of Minnesota Twin Cities | West Virginia University       |
| Texas A&M University      |                                      |                                 |

3.2 Keywords Coding and Classification

The organizational structure for an academic discipline usually consists of three levels in American universities. These three levels are listed as follows in a low-to-high order: the degree program level, the departmental level (sometimes refers to a unit or a school), and the college level (sometimes refers to a division). The same structure applies to water-related disciplines. We name the three organizational levels of water-related disciplines as water-related degree programs, water-related departments and water-related colleges just for convenience. Among them, water-related degree programs are the smallest units where water-related disciplines are developed. The program name reflects the specific research area and specialty of a water-related discipline, while a department or a college usually includes a wider range of research areas. To be accurate, a department usually contains
a number of research fields of the same discipline [5]. The department name embodies the range of research fields where water-related research is involved. The establishing of a college is usually based on a broader category of disciplines [6], and a college usually comprises of a group of different disciplines [7]. As a result, the name of a water-related college not only reflects a broad field category where the water-related discipline belongs to, but also reflects the interaction and integration between “pure” water discipline and other related disciplines. In this paper, we used the text analysis methods to classify and code the keywords of the names of water-related degree programs, departments and colleges. By doing so, we are able to identify the range of water-related research areas and examine the interdisciplinary nature of water-related disciplines.

We proposed a guideline to code and group key words appearing in the names of water-related degree programs, departments and colleges (see Table 2). The identification and classification of keywords has been advised and approved by several experts in the fields of water-related research. Taking the coding and grouping of programs as example, we judged whether the program name had the exact words from the keyword list, if yes, then the program was assigned to the category where the keyword belonged. Each program can be assigned to multiple categories. The departments and colleges are assigned to certain categories using the same method as we do to programs. To ensure the accuracy of coding, each item has been coded by two persons separately and cross-checked afterwards.

### Table 2. Guideline of keyword coding and grouping.

| Category                                | Levels | Keywords                                                      |
|-----------------------------------------|--------|---------------------------------------------------------------|
| Arts and sciences (AS)                  | C<sup>a</sup> | arts and sciences; liberal arts and sciences; letters and science; graduate school/division |
| Science and engineering (SE)            | D<sup>b</sup>/C | science and technology; science and engineering               |
| Science (SCI)                           | P<sup>c</sup>/D/C | math; physical; science; chemistry                            |
| Engineering and application (ENG)       | P/D/C  | civil; engineering; applied; computer; mine; architecture; house; fire; built; technology |
| Resource and environment (NRE)          | P/D/C  | environment; nature; desert; eco.; resource; conservation; natural |
| Biomedical science (BIO)                | P/D/C  | life; human; bio.; plant; evolution; organism; wildlife; entomological; health; animal |
| Agriculture, forestry, animal husbandry and fishery (AGR) | P/D/C  | agriculture; food; fishery; crop; soil; forest; rangeland; horticulture; irrigation |
| Earth science (GEO)                     | P/D/C  | atmosphere; earth; geo.; meteorology; climate; land; atmosphere; air; plane |
| Economic management and humanities social science (SOC) | P/D/C  | sustain; law; design; rural; social; urban; global; history; economic; management; policy; business; journalism |
| Pure water (WATER)                      | P/D/C  | hydrology; water; limnology; watershed; water resource       |

<sup>a</sup>. College level.

<sup>b</sup>. Department level.

<sup>c</sup>. Program level.

### 4. Interdisciplinary Status of Water-related Programs

The scope of water-related research fields and the interdisciplinary status of water-related disciplines can be judged by: a) whether the names of water-related programs, departments and colleges are assigned to multiple categories; b) what categories are mostly likely to appear in the names at the same time. Based on the differences in the meanings of names, the explanations and implications should be different. For example, the more categories a program name has been assigned to, the smaller and more focused research area the program has. In other words, the program will host a specific interdisciplinary research field. However, if a department name is assigned to multiple categories, this department tends to have a broader coverage of water-related research areas. Similarly, if a college
name is assigned to multiple categories, this college may host a collection of different disciplines which may lead to the formation of interdisciplinary research fields through interaction and integration between disciplines.

The rate of water-related programs, departments and colleges with assignments to multiple categories are 39.7%, 52.9% and 35.6% respectively. Through the figures, we can see that American public universities tend to educate students with a wide and broad major in water-related programs. More than 60% of the water-related degree programs are assigned to a single discipline category. While for the water-related departments, they have hosted a wider scope of disciplines or research fields. For more than half of the departments are assigned to at least two disciplinary categories. The figure for the water-related colleges matches expectation. Most of the colleges are built based on a single discipline category.

Later on, we will focus on the water-related programs, departments and colleges with multiple assignments, and examine the interdisciplinary nature behind these multiple assignments.

4.1 Interdisciplinary research fields

According to multiple assignments of water-related degree programs, the interdisciplinary research fields mainly include:

Firstly, the interdisciplinary fields of natural resources, environment and other academic disciplines are commonly developed in the water-related programs in American public universities. Among all the degree programs with multiple assignments, there are 36 degree programs assigned to “resources and environment” category and other categories at the same time (see Figure 1). For examples, the Civil and Environmental Engineering Program based at Utah State University and the Ecohydrological Engineering Program based at University of Idaho are assigned to both “resources and environment” category and “engineering and application” category; the Environment Science and Management Program based at University of Rhode Island and Environmental and Water Resource Economics Program based at University of Arizona are assigned to both “resources and environment” category and “economic management and humanities social science” category; the Environmental Soil Program based at Utah State University and Forest Resources and Environmental Conservation Program based at Virginia Polytechnic Institute and State University are assigned to both “resources and environment” category and “agriculture, forestry, animal husbandry and fishery” category.

Secondly, the interdisciplinary fields of agriculture, forestry, animal husbandry & fishery and other academic disciplines are also common in American public universities’ water-related programs. The number of this kind of degree program is 10, and the best example is Biological & Agricultural Engineering Program based at University of Arkansas, University of Idaho, Pennsylvania State University and Washington State University at the same time; the Environmental Management in Agriculture and Natural Resources Program based at University of Florida and Rangeland Ecology and Watershed Management Program based at University of Wyoming are assigned to “agriculture, forestry, animal husbandry and fishery” category, “resources and environment” category and “economic management and humanities social science” category at the same time.
4.2 Interdisciplinary research platforms

In the light of multiple assignments of water-related department, the data show that there are 56 two-category department platforms (see Figure 2). And “resources and environment” category discipline does not necessarily based at the “resources and environment” category department platform, for instance, in Oklahoma State University, the Environment and Natural Resources Program is based at the Department of Biosystems and Agricultural Engineering. In addition, there are 11 three-category department platforms which build-up by “agriculture, forestry, animal husbandry and fishery” category, “biomedical science” category and “engineering and application” category, accounting for 12% of the total. For example, the Biosystems and Agricultural Engineering Department provides Environmental Sciences Program in Oklahoma State University. To put it in a nutshell, water-related research platforms are developed with a various construction form.

Based on multiple assignments of water-related colleges, the “agriculture, forestry, animal husbandry and fishery” category is the prime participant, for example, Natural Resources Program based at College of Life Sciences and Agriculture in New Hampshire University, is assigned to both “agriculture, forestry, animal husbandry and fishery” category and “biomedical science” category; Natural Resources Management Program based at College of Agriculture, Food Systems in North Dakota State University is assigned to both “agriculture, forestry, animal husbandry and fishery” category and “resources and environment” category.

Figure 1. Distribution of water-related degree programs in multiple categories.

Figure 2. Distribution of water-related departments and colleges with multiple assignments.
5. Conclusions and implications
This study mainly focused on the interdisciplinary nature of water-related programs in American public universities. Through a text analysis of the names of water-related degree programs, departments and colleges, we found that American public universities had paid much attention to the applicability and diversity of water-related programs when developing interdisciplinary research fields. Here are some implications for China’s future strengthening interdisciplinary water-related research.

Firstly, it’s important to broaden the scope of water-related research through stronger interaction and integration of different disciplines. On the one hand, most of the water-related departments are acting as the platforms that consist of many other discipline categories; on the other hand, water-related colleges are mainly established as comprehensive research platforms. As a result, the water-related departments and colleges have both developed the water-related interdisciplinary in width and depth. Their departments and colleges lay emphasis on the construction of interdisciplinary platforms. For Chinese universities, it’s important to broaden the water-related research fields by cultivating new water-related interdisciplinary [7] [8]. Furthermore, the internal and external academic resources must be channeled to establish high-quality inter-disciplinary research platforms [9].

Secondly, strengthen the applicability of water-related interdisciplinary through creating applicative research platforms and cultivating talents with applicable abilities. Most of water-related interdisciplinary in American public universities focused on applied research and applied talents training. Water problems have both universal and national characteristics. As for the development of water-related interdisciplinary in China, we should encourage the cooperation between basic and applied water-related disciplines, such as environmental engineering, geological engineering, and agricultural engineering and so on. Humanities and social sciences should also be included in the cooperation to develop new water-related interdisciplinary such as water law. Most importantly, the development of water-related interdisciplinary in China should attend to solve this country’s own water problems.

Finally, break the linear relationship among the disciplines, departments and colleges to establish a diversified water-related interdisciplinary system [10]. First of all, the water-related departments and colleges should be allowed to develop degree programs from a different disciplinary category. For instance, in American public universities, some of the degree programs in “resources and environment” category are not host in the departments or colleges belonged to the same category, but hosted in the “earth science” category colleges. Besides, American public universities have developed several degree programs across the departments or colleges, or even co-hosted the programs with other universities. It is also good for the diversity of water-related inter-disciplinary system. Chinese universities should change and reform the traditional disciplinary system. It is a big step to break the linear relationship between departments and degree programs, and develop a flexible disciplinary system allowing for cultivating water-related interdisciplinary across the departments, colleges and even institutions.

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