

SAES-422 – NC1207 Accomplishments Report

Project/Activity Number: NC1207

Project/Activity Title: Collaborative for Research on Food, Energy, and Water Education

Period Covered: 10/01/2018 - 09/30/2023

Date of Report: 11/5/2020

Annual Meeting Dates: n/a (no annual meeting this year due to COVID)

Participants: Please see attached

Brief Summary of Minutes of Annual Meeting:

Our annual meeting was planned for June, 2020, in conjunction with the NSEC 2020 conference. However, due to COVID, this conference was shifted to a virtual format. Since our project leadership team and each of 3 working groups meets regularly (i.e., bi-monthly), we have continued to hold NC1207 coordinating meetings throughout the reporting period.

Short-term Outcomes:

- Empirical research results to address project objectives – we are currently in the final stages of completing a literature search of research on FEW-Nexus-based educational programs. Thus far, this search has yielded approximately 350 peer-reviewed articles that will be used by NC-FEW members to synthesize existing research. We have also collected and begun analyzing data collected from an onboarding survey of NC-FEW participants that will ultimately be used as a pre/post measure of impact of NC-FEW on participants.
- Increased capacity for NC-FEW to impact FEW-Nexus educational programming at institutional and national levels – nothing to report
- External funding to enhance sustainability and impact of NC-FEW (e.g., an NSF grant for a Research Coordination Network) – through NC-FEW communications, we have disseminated federal funding opportunities to NC-FEW participants. We also have a webinar scheduled for 11/13 in which an NSF HER program officer will provide an overview of funding programs that could be of interest to NC-FEW participants.

Outputs: We have implemented our dissemination and recruitment plan, resulting in over 160 NC-FEW participants. Though our plans were disrupted by COVID, we continue to move forward with dissemination and recruitment. The research synthesis and project evaluation efforts are ongoing. NC-FEW's mission statement and objectives (<http://ncfew.org/about/>) are firmly established and are reflected in the work of the community thus far and planned into the future. We recently put out a preliminary call for contributions to an edited book focused on FEW-Nexus educational approaches and strategies. We also organized a Virtual Showcase for NC-FEW members to disseminate their work.

Activities:

- Bi-monthly meetings of leadership team and working groups
- Quarterly webinars and newsletters
- Literature search
- Participant data collection and analyses
- Dissemination and recruitment

Milestones: We are in Year 2 of the Multistate project and associated NSF-funded project. Though work is proceeding, it is doing so at a slower pace than originally anticipated, in part due to disruptions caused

by COVID. By summer, 2021, we hope to have working drafts/white papers for a) literature reviews/research syntheses and b) standards crosswalks. These products will lay the foundation for work yet to come (collaborative proposal development, development of teaching tools, invited conferences, etc.). They will also be publishable products in their own right, enhancing the impact of the NC-FEW community.

Impacts: To enhance learning about coupled human-natural systems, educators need resources and tools specifically designed for this purpose. NC-FEW will synthesize prior research on FEW-Nexus-based educational programs, use this information to develop resources, models, and tools for FEW-Nexus-focused education, and assume a critical leadership role in nucleating new, novel, and innovative discipline-based education research that foregrounds food, energy, and water systems. Thus far, this community has grown to over 160 members nationwide, reflecting the priority this domain if work is afforded, as well as the transdisciplinary nature of individuals doing this work. While most NC-FEW impacts are yet to be realized in this early-stage phase of work, the groundwork the community is engaged in now is essential to enable to more tangible, outcome- and product-driven work to follow, all of which has the strong potential to impact FEW-Nexus-based education across 'K-gray' in formal and informal/non-formal educational contexts.

Presentations:

Forbes, C.T. (invited, 2020, August). *Sustainability Education in the Food-Energy-Water-Nexus*. Invited presentation at Association for the Advancement of Sustainability in Higher Education (AASHE) Webinar Series. (Virtual presentation due to COVID-19)

Forbes, C.T. (invited, 2020, April). *Research on education in the Food-Energy-Water-Nexus: Opportunities and challenges for STEM educators and education researchers*. Invited presentation at the Center for Research in Mathematics and Science Teacher Development, University of Louisville, Louisville, KY. (COVID-19 related cancellation)

Forbes, C.T. (invited, 2020, April). *Education research in the Food-Energy-Water-Nexus: Transdisciplinary opportunities for geography education*. Invited presentation at the 2020 meeting of the American Association of Geographers (AAG) session *Transformative Research in Geography Education*. (COVID-19 related cancellation)

Forbes, C.T., Campbell, T., & Roehrig, G. (2020, January). *Educator preparation in the Food-Energy-Water-Nexus: Building capacity for research through transdisciplinary networks*. Presentation at the annual meeting of the Association for Science Teacher Education (ASTE), San Antonio, TX.

Forbes, C.T., Scherer, H., Wang, H-H., & Sintov, N. (invited, 2020, June). *A national collaborative for food, energy, & water education*. Virtual presented at the 2020 annual meeting of the Network of STEM Education Centers (NSEC). (Virtual presentation due to COVID-19)

Forbes, C.T., Scherer, H., Sintov, N., & Wang, H-H. (2020, April). *A national collaborative for research food, energy, & water education*. Poster presented at annual meeting of the American Association of Geographers (AAG), Denver, CO. (COVID-19 related cancellation of conference)

Publications:

Scherer, H. H., Forbes, C. T., Sintov, N., & Wang, H.-H. (2020). The Food-Energy-Water-Nexus: A new way to help students think about resource management in AFNR education. *The Agricultural Education Magazine*, 92(5), 5-8.

Teasdale, R., Scherer, H., Holder, L., Boger, R., & Forbes, C.T. (2018). [Research on teaching about Earth in the context of societal problems](https://doi.org/10.25885/ger_framework/5). In K. St. John (Ed.), *Community Framework for Geoscience Education Research* (pgs. 49-60). National Association of Geoscience Teachers. Retrieved from https://doi.org/10.25885/ger_framework/5.

Post-secondary working group – Annual report material

1. Synthesize current education research on educational programming grounded in the FEW-Nexus

Addressing complex FEW-Nexus challenges requires interdisciplinary knowledge and skills and involves tradeoffs to develop solutions that are cost-effective, environmentally sustainable, socially responsible, and acceptable to consumers. Therefore, the FEW-Nexus problem space offers a prime context for supporting learners of all types in learning about, applying, and integrating ideas and methods across diverse disciplines. The goal of the postsecondary education working group is to leverage the FEW-Nexus to understand and strengthen approaches to interdisciplinary STEM/FANH education amongst postsecondary students. We plan to accomplish this by: (1) framing a set of student learning outcomes that promote interdisciplinary thinking and problem solving among undergraduate and graduate learners; (2) identifying empirically-supported measures of these outcomes; and (3) identifying and/or developing resources (e.g., curricular elements and sequencing) that can support educators in engaging and supporting postsecondary learners in achieving these outcomes. To these ends, the post-secondary working group has collected literature on barriers to interdisciplinary and how the FEW Nexus can address them. We have also been developing an outline and working towards a perspective/review manuscript on this topic.

2. Identify and promote best practices in education research on educational programming grounded in the FEW-Nexus

As part of our literature review effort described above, we have been identifying approaches for overcoming barriers to interdisciplinary education efforts. We plan to continue collecting evidence-based best practices and to compile these into a set of recommendations.

3. Foster collaboration among community members representing diverse disciplines, fields, expertise, and institutions

The post-secondary working group brings together individuals from the following institutions to work towards shared goals: The Ohio State University, University of Nebraska-Lincoln, University of Vanda, Northern Colorado University, and The New School. The disciplines represented by these individuals span chemistry, education research, psychology, natural resources management, and rural development.

4. Enhance capacity for extramural funding in support of education research on educational programming grounded in the FEW-Nexus

One of our working group members, Chelsie Romulo, won an NSF IUSE award in April 2020 (#2013373: Developing a Next Generation Concept Inventory to Help Environmental Programs Evaluate Student Knowledge of Complex Food-Energy-Water Systems). She will lead development of a program that will assess students' understanding of the connections among food-energy-water concepts in their classes.

5. Cultivate a community identity among NC-FEW participants

Nothing specific to report here.

1. *Synthesize current education research on educational programming grounded in the FEW-Nexus*

The in/non-formal education working group made initial steps toward synthesizing current research by identifying scholarship that is foundational to the work of each member. We assembled a bibliography of 23 scholarly publications that collectively represent the theoretical and empirical work that the working group sees as relevant to education in the FEW-Nexus. Drawing on this diverse array of publications and foundational documents such as the National Academies (2009) publication *Learning Science in Informal Environments: People, Places, and Pursuits*, we initiated efforts to develop an organizing framework for in/non-formal FEW-nexus education, communication, and equitable stakeholder engagement.

2. *Identify and promote best practices in education research on educational programming grounded in the FEW-Nexus*

The primary accomplishment of the in/non-formal education working group within this area was to identify a goal which will guide future work. Our goal is to identify and share emerging possibilities for FEW-Nexus education and communication in informal and nonformal settings in service to science learning, environmental justice, and sustainability. We will utilize our framework for in/non-formal FEW-nexus education, communication, and equitable stakeholder engagement in order to (1) describe innovative cases where this work is already happening, (2) investigate new possibilities, and (3) share methods and models with the broader community.

3. *Foster collaboration among community members representing diverse disciplines, fields, expertise, and institutions*

During the first project year, the in/non-formal education working group expanded and membership evolved to include a more diverse range of disciplines; the majority of members had not previously collaborated with each other. There were 7 working group meetings during the project year. Current working group members conduct work in community learning about climate change, human dimensions of natural resource management, program evaluation, using socio-environmental systems to positively impact quantitative skills in STEM across socio-economic divides, environmental education and civic engagement, science communication and engagement, and connections among formal and informal science learning environments. This diversity will allow us to expand NC-FEW efforts into a large array of disciplinary and institutional spaces.

4. *Enhance capacity for extramural funding in support of education research on educational programming grounded in the FEW-Nexus*

5. *Cultivate a community identity among NC-FEW participants*

The in/non-formal education working group developed a shared vision and goal, as expressed in our Overview and Goals contribution to the [Summer 2020 NC-FEW Newsletter](#).

K-12 working groups

The core members in the K-12 working group are Drs. Todd Campbell (University of Connecticut), Sarah Fick (Washington State University), Doug Lombardi (University of Maryland), Aaron McKim (Michigan State University), Gill Roehrig (University of Minnesota), and Hui-Hui Wang (Purdue University). The overarching goal of K-12 working group is to foreground the food, energy, and water nexus (FEW-Nexus) as central to scientific literacy for K-12 learners that is supportive of a sustainable future and necessary for responsible citizenship. Specifically, the K-12 working group focuses on (1) examining, and refining how FEW-Nexus scientific literacy can be embodied in performances of K-12 learners; and (2) identifying and developing educational resources to support K-12 educators. In the first year of NC-FEW, the K-12 working group worked on the following activities that are fall within the five project goals.

1. Synthesize current education research on educational programming grounded in the FEW-Nexus

The K-12 working group synthesized the Next Generation Science Standards (NGSS Lead States, 2013) to find themes that relate to FEW-Nexus complex problems. For example, energy and matter, and systems and system models are crosscutting concepts in the high school NGSS that associated with FEW-Nexus. By closely examining the NGSS, the K-12 working group aimed to identify and map the overlap between existing standards and FEW-Nexus sustainability topics, while also seek to design and refine pedagogical supports with K-12 teachers.

2. Identify and promote best practices in education research on educational programming grounded in the FEW-Nexus

Besides FEW concepts, the K-12 working group also identified three educational goals that relate to FEW-Nexus sustainable thinking as the potential research topics, (1) Learning/phenomenon progression; (2) System thinking; and (3) Argumentation/evidence-based reasoning.

3. Foster collaboration among community members representing diverse disciplines, fields, expertise, and institutions

The K-12 working group met at least once of every month to share visions and brainstorm potential opportunities to collaborate. These meetings focused on how we could best utilize each core members' expertise to help support the efforts of FEW-Nexus.

4. Enhance capacity for extramural funding in support of education research on educational programming grounded in the FEW-Nexus

The K-12 working group submitted a proposal to USDA/NIFA Professional Development for Agricultural Literacy Grants. The proposed project addresses the needs of interdisciplinary teams working to empower K-12 educators to utilize locally-relevant challenges in the FEW-Nexus to (a) empower learners to think systemically about authentic problems, (b) address the NGSS (NGSS Lead States, 2013) and National Agriculture, Food, and Natural Resources Standards via locally-contextualized problems, and (c) increase student awareness and interest in FANH STEM careers.

5. Cultivate a community identify among NC-FEW participants

The K-12 working group has not been able to cultivate a community to include broader audiences due to at the early stage of the NC-FEW project. The K-12 working group has prioritized the tasks around seeking input from the core members to identify the goal of the K-12 working group and establish the "reasonable" workload for each individual.

References:

NGSS Leader States. (2013). *Next Generation Science Standards: For states, by states*. Washington, DC:

National Academics Press. www.nextgenscience.org/next-generation-science-standards.

Enhancing Teaching and Learning About the Food-Energy-Water-Nexus:

Who are Postsecondary Reformers in NC-FEW?

Abstract

Food, energy and water (FEW) are critical systems for humanity and subject to rapidly growing global demand compounded by climate change. The inter-dependency among these resources is multidimensional, requiring an effective and coordinated Nexus approach. These challenges provide a rationale for sustained, systemic, and interdisciplinary educational efforts focused on food, energy and water systems in a wide array of educational contexts. The National Collaborative for Research on Food, Energy, and Water Education (NC-FEW) is an NSF-funded, emergent, transdisciplinary community of postsecondary educators and education researchers from diverse disciplinary backgrounds engaged in sustained network- and capacity-building. Here, we present preliminary findings from an onboarding survey of 143 members of the NCFEW community working in different educational contexts to better understand the depth of their FEW-Nexus knowledge base, confidence with FEW-Nexus teaching and education research, and sense of community affiliation. Results show that NC-FEW members are able to characterize FEW-Nexus concepts with approximately 80% accuracy. Participants were more confident about general teaching & research abilities (Mean=3.8) than with FEW-Nexus teaching & research proficiency (Mean=3.3). A paired t-test validated the statistical significance of this observed difference. Also, results demonstrate that participants feel connected to the community of FEW Nexus educators only to some extent. These findings indicate the presence of ambiguity in the perception of the FEW-Nexus concept among NC-FEW community members, which calls for further clarity and development. Additionally, the importance of organizing FEW-Nexus education training and workshops to boost members' confidence and strengthening the sense of community affiliation was highlighted by this study, therefore having important implications for ongoing NCFEW community activities and broader postsecondary reform efforts.

Keywords: FEW-Nexus, teaching, community, education research

Introduction

The greatest challenges of the 21st Century and beyond are defined by interactions between natural and human systems. The Food-Energy-Water-Nexus (FEW-Nexus) provides a framework for understanding these interactions. While the FEW-Nexus has received increasing attention in scientific research, educational programming and research on teaching and learning grounded in the FEW-Nexus has been underemphasized. There is a need to build upon work from individual disciplines to systematically advance FEW-Nexus-based educational efforts in a transdisciplinary manner. To begin to address these needs, we will cultivate a new, novel, transdisciplinary community of educators and education researchers whose work focuses on the teaching and learning about the FEW-Nexus in science, technology, engineering, and mathematics (STEM) and food, agriculture, natural resources, and human sciences (FANH). The fundamental assumption underlying this project is that the FEW-Nexus affords a novel theoretical and analytical lens through which to foster and understand teaching and learning about contemporary FEW challenges. This project will enable NC-FEW's development as a networked improvement community that can provide leadership for education research on educational programming grounded in the FEW-Nexus. Through systemic capacity-building activities and collaborative research, project activities will advance knowledge and practice about teaching and learning in the FEW-Nexus, including pedagogical practices, student learning, and evaluation and assessment, with a novel focus on the FEW-Nexus and mobilization of transdisciplinary expertise to catalyze education research around innovative FEW-Nexus educational programs. The proposed project is a direct response to calls for education research on teaching and learning in STEM and FANH sciences. It is grounded in and will contribute to theory and research on teaching and learning in diverse disciplinary contexts and about contemporary global challenges, as well as associated STEM and FANH concepts, which span FEW systems. Finally, because NC-FEW is unlike any existing professional community, the project will synergize the unique collaborations that are necessary to bring new,

transdisciplinary perspectives to bear on education research grounded in the FEW-Nexus. These new collaborations and empirical insights will contribute to the development and implementation of new, innovative, and collaborative FEW-Nexus education endeavors involving NC-FEW community members that advance INFEWS program goals, as well as those of other NSF and USDA-NIFA programs.

Mission:

A sustained, systemic, and interdisciplinary education initiative, including program evaluation and discipline-based education research (DBER), focused on Food-Energy-Water-Nexus (FEW-Nexus) spanning a wide array of contexts. Education program and empirical research are unified by core models, strategies and commitments, but implemented in diverse ways reflecting unique elements of localized FEW-Nexus issues. This approach uses novel theoretical and analytical perspectives emphasizing coupled human-natural systems as the core element of postsecondary teaching and learning within the FEW-Nexus.

Goals:

1. Advance effective, research-based FEW education efforts
2. Foster FEW education research to evaluate the effectiveness of FEW education programs
3. Enhance collaboration around FEW-Nexus education that aids in educational responsiveness to emergent FEW issues and catalyzes robust DBER

Prospective NC-FEW participants may hold varying conceptions of FEW and will likely bring an array of perspectives to bear on this emerging community. This diversity of perspectives is one of many arguments for the transdisciplinarity of the NC-FEW community, as highlighted in the proposal. The charge for the project leadership team involves two reciprocal considerations: leveraging the unique

perspectives and expertise of each NC-FEW participant and collectively working towards a shared understanding of fundamental components of community-specific ideas.

Method

Instrument

An online onboarding survey through Qualtrics was administered where 143 members of the NC-FEW community participated in. They are from different educational background working in different educational contexts. The participants were asked various questions regarding their perspective about FEW-Nexus, their teaching methods, confidence and education research.

FEW-Nexus Knowledge:

Participants were asked to answer several questions related to food, energy and water concepts. They were given the options of selecting the statement as either correct or incorrect. This is important because it provides the opportunity to understand their FEW-Nexus knowledge base and interest in this sector. It would help to design different training programs/ workshop to enhance their knowledge and confidence level.

Confidence with Teaching and research:

Participants were asked to rate their teaching/research abilities for general programs and FEW-Nexus based programs so that gaps could be identified. The categories ranged from “Novice” to “Expert” (Category-1). To determine the confidence levels of NC-FEW members in General & FEW focused teaching & researches the participants were asked to characterize their proficiency according to their perception in different aspects of teaching & education research for general educational programs & FEW-Nexus based educational programs in order to distinguish their abilities between these sectors.

There were five rating categories for each statement which were imposed individual scores for the purpose of calculating the overall composite score for both programs.

Community Affiliation:

Another important factor of analysis is determining the level of community affiliation between the participants. To determine the extent to which participants share their goal, values and philosophies for FEW-Nexus teaching and research, they were asked to identify their level of interaction between the NC-FEW community members. The interaction level ranged from 'Not at all' category to "A great extent" category (Category-2). To determine the sense of affiliation with the NC-FEW community, different questions were asked to the participants. First, respondents answered to the question "To what extent do you consider yourself part of a community of educators & education researcher that share your goals, philosophy & values for FEW-Nexus education? "Those respondents who provided an answer other than 'not at all" (n=103), they were then asked an additional series of questions.

Participants' were asked to determine the interaction level that helped them to become a better educator/ teacher. These qualitative categories were converted to quantitative scale for the purpose of further analysis. The categorical level and their quantitative scales ranged are as below-

Table-1

Categorical level and their quantitative scale-

Category-1	Scale-1	Category-2	Scale-2
Expert	5	To a great extent	3
Above Average	4	To some extent	2
Average	3	Only a little	1
Below Average	2	Not at all	0
Novice	1		

So, these quantitative scores are then used for further analyzing the participants qualitative answers. These data were analyzed using Microsoft excel and SPSS software. T-test, regression analysis and ANOVA test were performed throughout the analysis to signify the observed differences and establish different relationships.

Sample

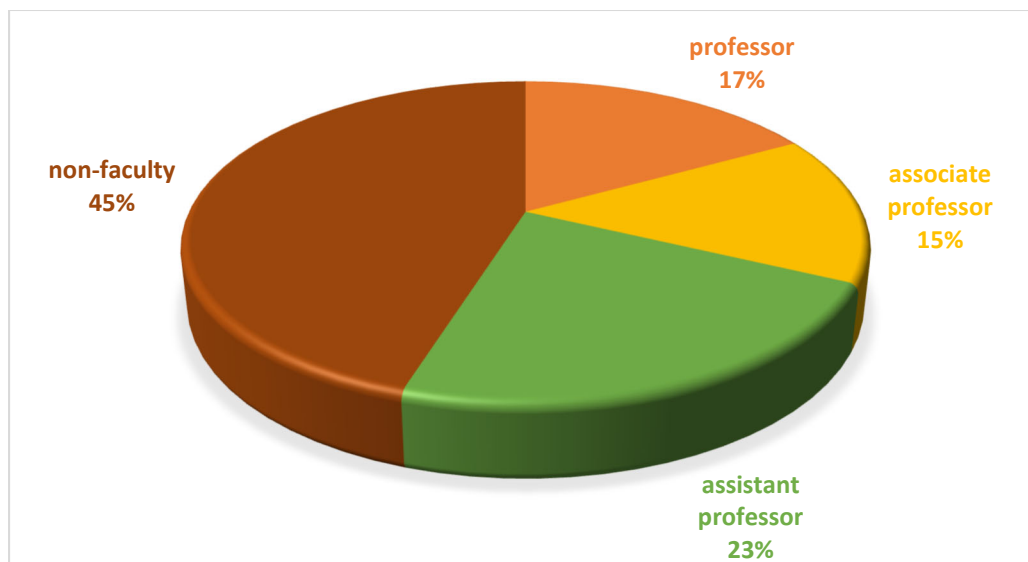
165 members of NC-FEW community participated in this survey. It is important to understand the participants background, educational context, disciplinary identity for further analysis regarding their FEW-Nexus activities.

Current position/ professional roles of the participants:

Most of the participants hold the role of non-faculty (45%). The other categories are- Assistant professor (23%), Professor (17%), Associate Professor (15%).

Figure-1

Professional roles of participants

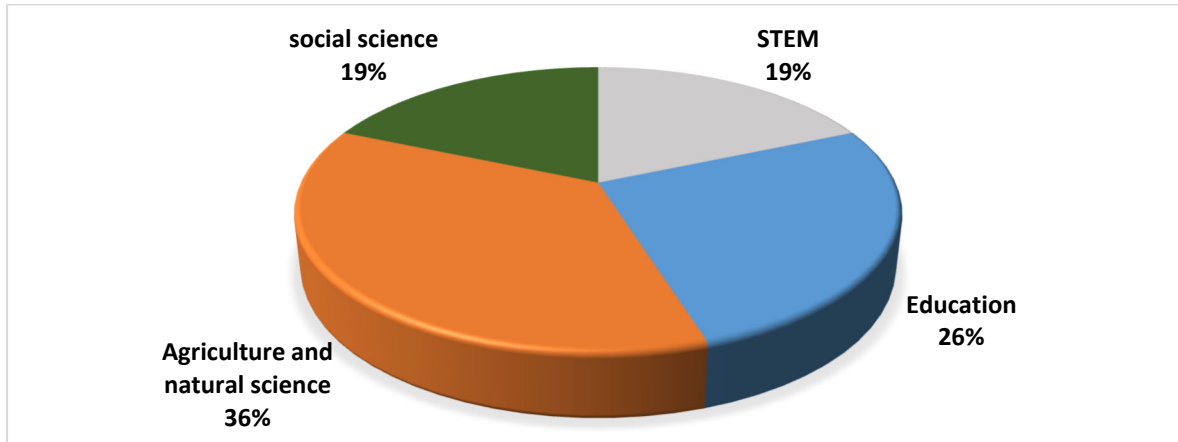


Disciplinary Identities of the participants:

the participants are from diversified disciplines, including- Agricultural and natural sciences (36%), Education (26%), social science (19%), STEM (19%).

Figure 2

Disciplinary Identities of the participants

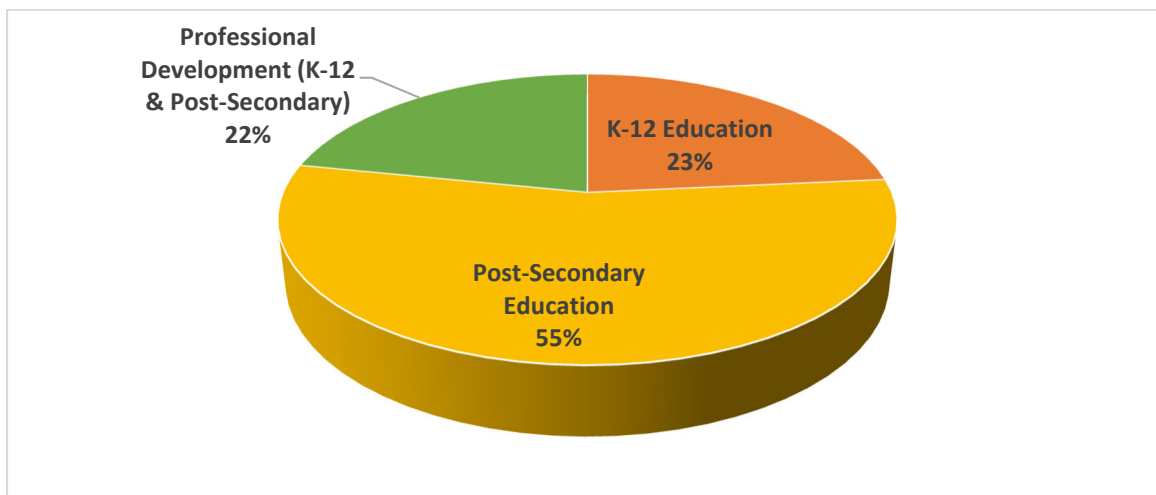


Educational context of the participants-

participants are affiliated with different educational context, including- undergrad education (23%), K-12 education (16%), youth focused (10%) and so on.

Figure 3

Educational Context of participants



Results

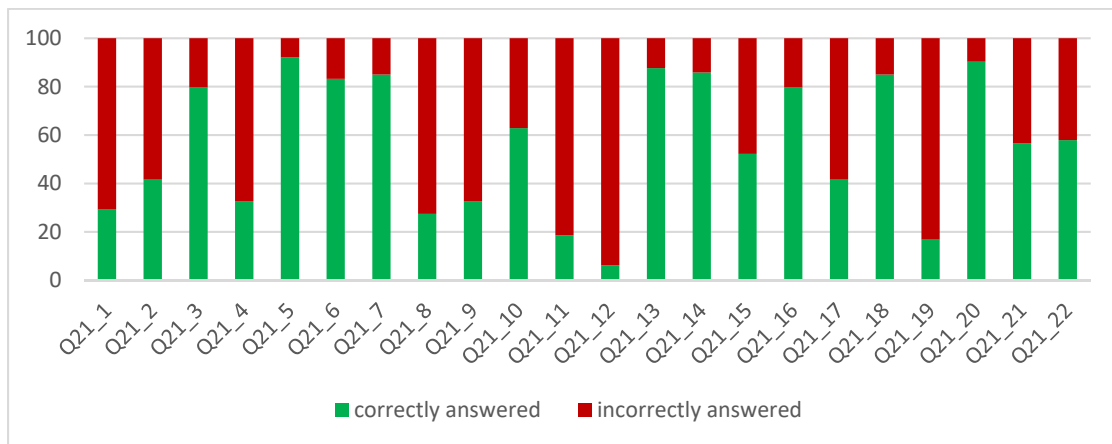
Participants' FEW-Nexus Knowledge Base

In research question-1, we asked, “What are NC-FEW participants’ levels of understanding of the FEW-Nexus?”. The first set of result answers this research question. A set of 22 items were presented to survey respondents, for each of which they answered either correct or incorrect. The overall trends in responses at the item level are shown in Figure 4. Results show that NC-FEW members are able to characterize FEW-Nexus concepts with approximately 56.57% accuracy (Figure-4). There were no items that respondents answered 100% correctly or incorrectly. Accurate response level ranged from 92% to 7%.

Results demonstrate that participants mostly struggled with answering questions related to agricultural water, discarded water, water withdrawal trend, manufacturing water, food requirement prediction related concepts where their accurate responses ranged from 6.19% to 32.7%. Participants’ were seen to respond most correctly in topics related to Global water demand, irrigation water, energy cost where their accuracy level ranged from 92% to 85.8%.

Figure 4

Percentage of Correctly answered questions-



The color coding is shown here-

Correctly answered (percentage)	Color coding	Level of Knowledge Base
(0-41) %		Low
(41-60) %		Medium
(61-100) %		High

	Statements	Correctly answered (Percentage)
1	What is the FEW-Nexus? - Agriculture accounts for the second largest amount of water used by human activities	29.20
2	What is the FEW-Nexus? - Food production and distribution account for roughly 10% of global energy use	41.59
3	What is the FEW-Nexus? - Industry accounts for approximately 20% of global water use by humans	79.65
4	What is the FEW-Nexus? - Approximately 70% of global water use by industry is associated with manufacturing	32.74
5	What is the FEW-Nexus? - Global water demand (in terms of water withdrawals) is projected to increase by 25% between 2015 and 2050	92.04
6	What is the FEW-Nexus? - Approximately 4 in 5 human beings are projected to be living in areas of severe water stress by 2050	83.19
7	What is the FEW-Nexus? - Globally, energy demand is projected to increase by one third by 2035, with demand specifically for transportation expected to grow by 70%	84.96
8	What is the FEW-Nexus? - By 2050, 20% more food will need to be produced (compared to 2015) in order to feed the world's population	27.43
9	What is the FEW-Nexus? - In 2017, nearly 15% of US corn was converted into ethanol	32.74
10	What is the FEW-Nexus? - Nearly half of all water withdrawals – both freshwater and ocean water – in the U.S. are used for cooling at thermoelectric power plants	62.83
11	What is the FEW-Nexus? - 10% of all freshwater consumed in the US is associated with discarded food (i.e., food waste)	18.58
12	What is the FEW-Nexus? - Hydraulic fracturing - a process to remove natural gas from the ground - uses water and this amount has increased more than 500% since 2011	6.19
13	What is the FEW-Nexus? - Periods of drought can mean that an individual power plant cannot produce as much electricity	87.61

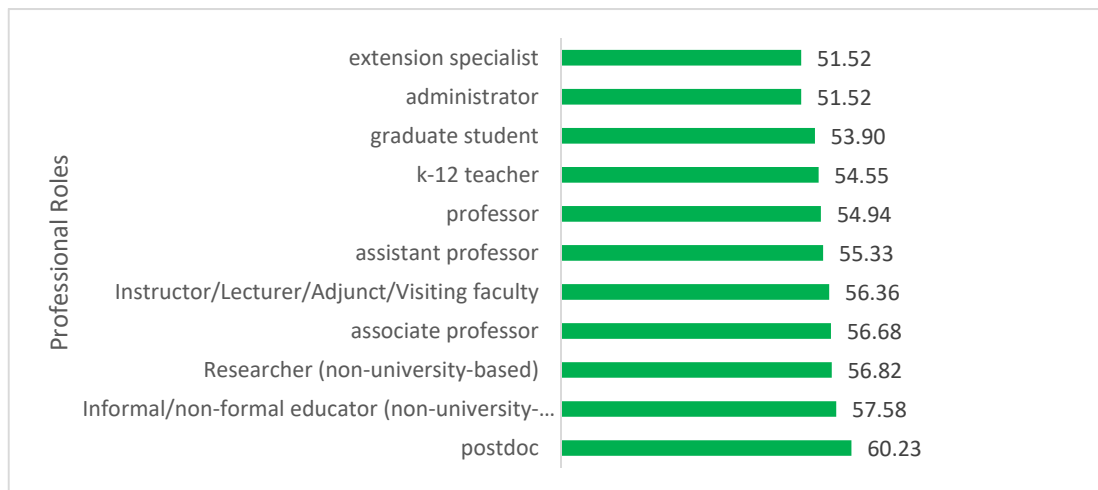
14	What is the FEW-Nexus? - Crop irrigation in the U.S. uses more groundwater than all other uses combined	85.84
15	What is the FEW-Nexus? - Energy use in U.S. agriculture has declined by more than 5% since the 1970s	52.21
16	What is the FEW-Nexus? - Global water demand for manufacturing is predicted to increase by 400% from 2000 to 2050	79.65
17	What is the FEW-Nexus? - Groundwater provides drinking water to less than 20% of the global population	41.59
18	What is the FEW-Nexus? - Globally, over 40% of all of the water used for irrigation is groundwater	84.96
19	What is the FEW-Nexus? - Freshwater withdrawals for energy production account for over 30% of the world's total and are expected to increase by 50% through 2035	16.81
20	What is the FEW-Nexus? - Electricity accounts for more than 50% of the total operating cost of water and wastewater utilities	90.27
21	What is the FEW-Nexus? - Globally, average cropland and irrigation water use for biofuels is predicted to remain under 5% of the total in 2030.	56.50
22	What is the FEW-Nexus? - It takes approximately the same amount of water to produce a gallon of ethanol and a gallon of crude oil: 3-5 gallons	57.87

To investigate trends in participants' knowledge, we also analyzed mean scores for knowledge of the FEW-Nexus across participants' professional roles and disciplines.

[Figure-5](#) shows the average level of accurate response on FEW-Nexus concepts based on professional roles. Results shows that accuracy level is highest for postdocs (60.2%) and lowest for extension specialists' (51.52%). Results from a one-way ANOVA ([Table-2](#)) shows that there wasn't an effect of professional role on FEW-Nexus knowledge at the $p < .05$ level, $F(11, 252) = 0.167$, $p = .999$ which is not less than .05.

Figure 5-

Knowledge base considering professional roles-

**Table 2-**

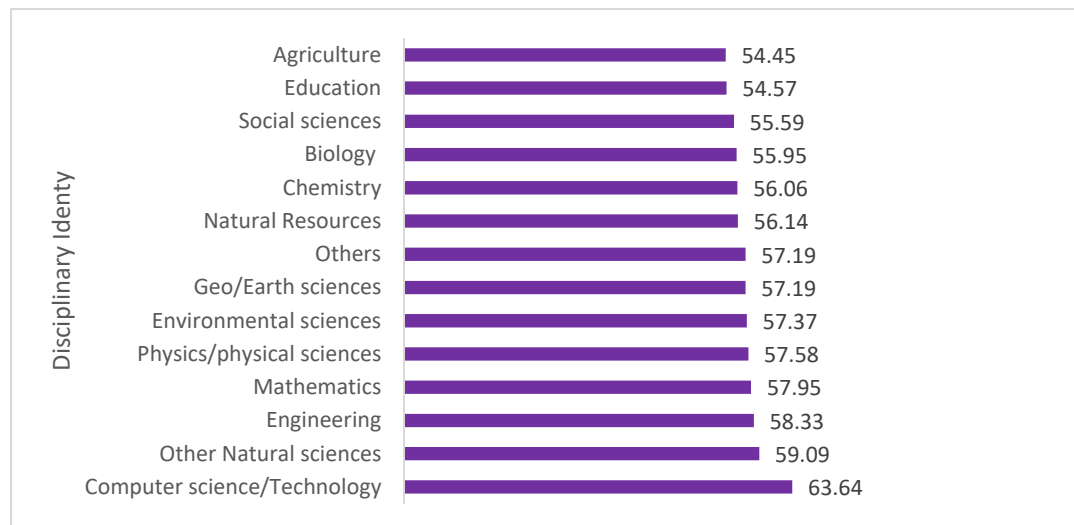
One-way ANOVA test for effect of professional role on FEW-Nexus knowledge

ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1922.140	11	174.740	.167	.999
Within Groups	264076.003	252	1047.921		
Total	265998.143	263			

[Figure-6](#) shows the average level of accurate response on FEW-Nexus concepts based on disciplinary identities. Results shows that accuracy level is highest for Computer-Science disciplinary professionals (63.64%) and lowest for Agricultural professional (54.45%). Results from a one-way ANOVA ([Table-3](#)) show that there wasn't an effect of discipline on FEW-Nexus knowledge at the $p < .05$ level, $F(11,252) = 0.102$, $p = 1.00$; which is not less than 0.5.

Figure 6-

Knowledge base considering Disciplinary Identities-

**Table 3-**

One-way ANOVA test for effect of disciplinary identities on FEW-Nexus knowledge

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1090.214	11	99.110	.102	1.000
Within Groups	245362.683	252	973.661		
Total	246452.897	263			

Confidence with Research and Teaching

In research question #2, we asked, “What are NC-FEW participants’ confidence levels with general and FEW-Nexus-specific teaching and research?” Results from this analysis suggests that FEW-Nexus teaching & research abilities are lower than compared to general educational programs. We detail these results in the subsections that follow.

Difference of confidence in general and FEW-Nexus teaching?

Mean scores were higher for general teaching than FEW-Nexus teaching. We compared mean scores for participants' reported confidence with general teaching abilities and FEW-Nexus teaching abilities. A paired sample t-test was conducted to compare participants confidence levels in teaching abilities between general programs and FEW-Nexus based programs. There was a significant difference in confidence with general teaching abilities (M= 4.03, SD=.77) and confidence with FEW-Nexus based teaching abilities (M=3.43, SD=.92), $t(106) = 7.88$, $p = 0.0000000000276$; which is less than .05, so we can reject the null hypothesis and state that the observed difference is significant. ([Table-4](#))

Figure 7

Abilities with Teaching/Instruction in General & FEW-Nexus-Based Educational Programs

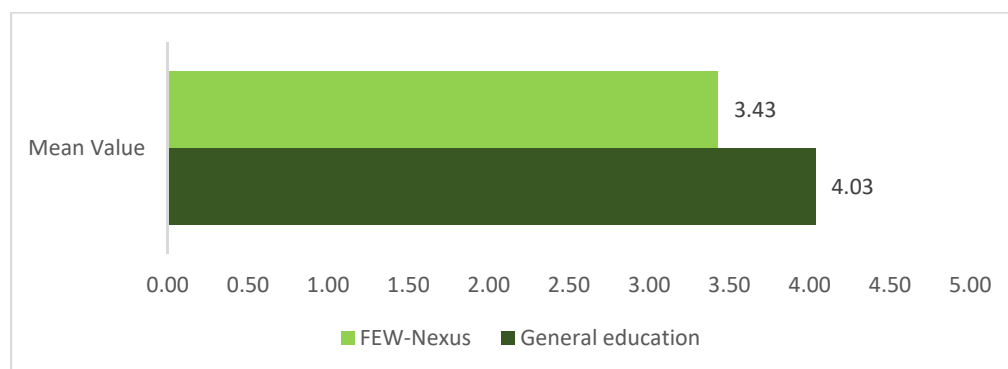


Table 4

Paired Sample T-Test for confidence with teaching abilities

Mean Confidence Level	M	N	SD	t	df
General Teaching abilities	4.03	107	.76984		
FEW-Nexus Teaching Abilities	3.43	107	.92127	7.88	106

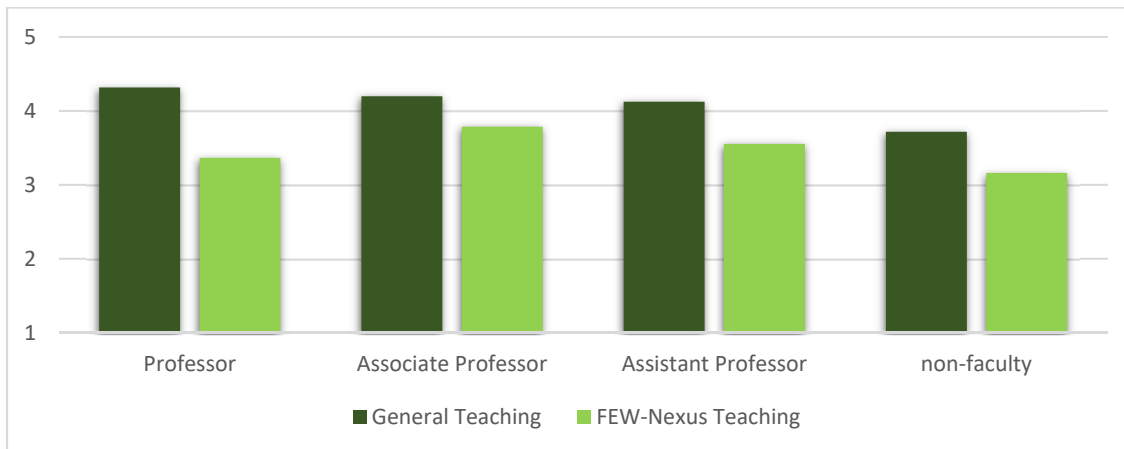
We also conducted analyses to analyze these trends by professional role and discipline. To understand the difference of confidence level ([Figure-8](#)) among the participants based on their professional roles, one-way ANOVA and POST-HOC analysis was performed.

Results from a one-way ANOVA shows that there was an effect of professional role on confidence level while teaching general programs at the $p < .05$ level, $F(2.22, 1.15) = 25.7$, $p = 0$; which is less than .05.

Again, Results from a one-way ANOVA shows that there was an effect of professional role on confidence level while teaching FEW-Nexus programs at the $p < .05$ level, $F(2.34, 1.17) = 26.7$, $p = 0$; which is less than .05. So, the ANOVA showed the existence of significant confidence level difference for teaching general and FEW-Nexus programs.

Figure 8-

Mean confidence in teaching abilities based on professional roles:



Based on the Post-HOC test, Professional role number-1 (Professor), role number-2 (Associate Professor) and role number-3 (Assistant professor) have statistically significant confidence difference with professional role number 4 (Non-Faculty) for general teaching abilities. There's no confidence difference among role number-1,2,3.

Again, based on the Post-HOC test, Professional role number-2 (Associate Professor) and professional role number-4 (non-faculty) have statistically significant confidence difference with all

other roles- (Professor, Assistant professor) for FEW-Nexus teaching abilities. there's also confidence difference among Associate professor and non-faculties. ([Appendices](#))

Confidence level for teaching abilities based on Disciplinary identities:

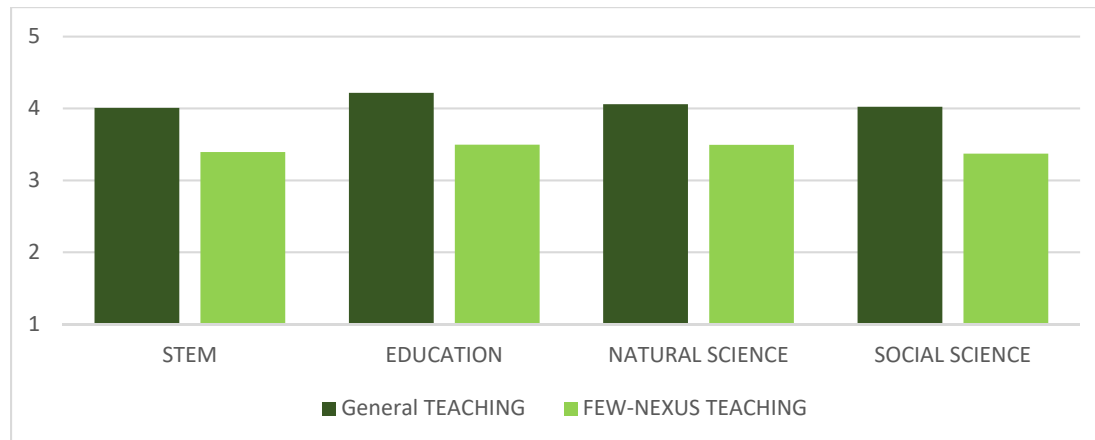
To understand the difference of confidence level among the participants based on their disciplinary identities ([Figure-9](#)), ANOVA and POST-HOC analysis was performed.

Results from a one-way ANOVA shows that there was an effect of disciplinary identities on confidence level while teaching general programs at the $p < .05$ level, $F (.303, 1.04) = 3.86$, $p = .016$; which is less than .05.

However, Results from a one-way ANOVA shows that there was no effect of disciplinary identities on confidence level while teaching FEW-Nexus programs at the $p < .05$ level, $F (.14, .91) = 2.07$, $p = .119$; which is more than .05. The ANOVA showed the existence of significant confidence level difference for teaching general program programs based on disciplinary identities; but not for teaching FEW-Nexus programs.

Figure 9-

Mean confidence in teaching abilities based on disciplinary identities:



Based on the Post-HOC test, Education discipline has statistically significant confidence difference with STEM and Social Science discipline for general teaching abilities.

Difference of confidence in general and FEW-Nexus Education Research?

Mean scores ([Figure-10](#)) were higher for general education research than FEW-Nexus education research. We compared mean scores for participants' reported confidence with general education research abilities and FEW-Nexus research abilities. A paired sample t-test was conducted to compare participants confidence levels of education research between the programs. There was a significant difference in confidence with general education research (M= 3.61, SD=.96) and confidence with FEW-Nexus based education research (M=3.18, SD=1.03), $t(103) = 5.798$, $p = 0.0000000001198$; which is less than .05, so we can reject the null hypothesis and state that the observed difference is significant. ([Table-5](#)).

Figure 10

Abilities with Education Research in General & FEW-Nexus-Based Educational Programs

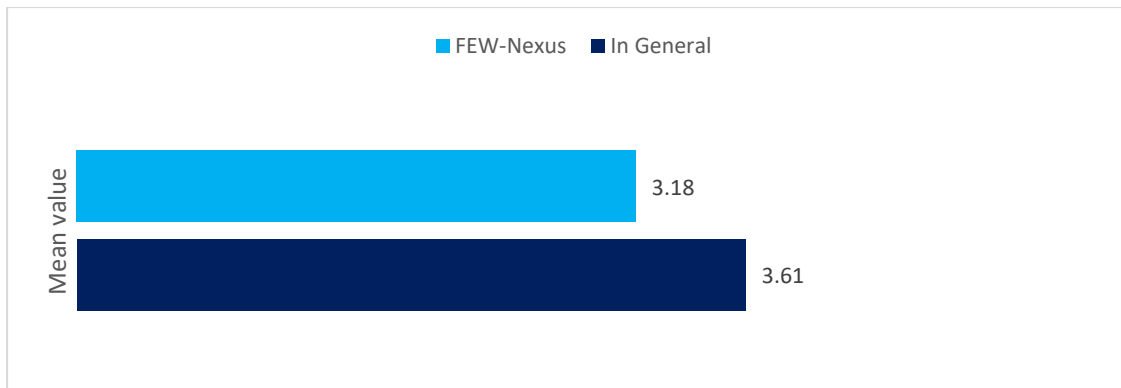


Table 5

Paired Sample T-Test for confidence with Education Research

Mean Confidence Level	M	N	SD	t	df
General Education Research	3.61	104	.96	5.798	103
FEW-Nexus Education Research	3.18	104	1.03		

We also conducted same analyses to analyze these trends for education research by professional role ([Figure-11](#)) and disciplinary identities ([Figure-12](#)).

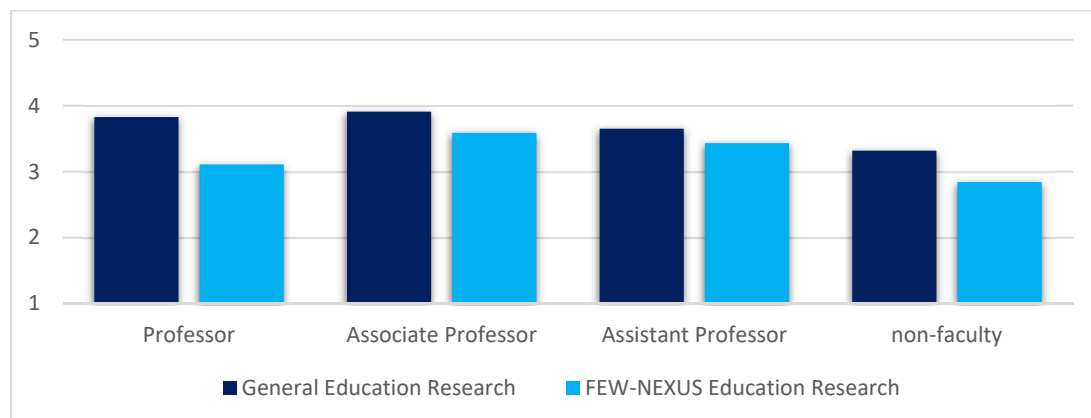
Confidence level for education Research based on Professional Roles:

To understand the difference of confidence level among the participants based on their professional roles, ANOVA and POST-HOC analysis was performed. Results from a one-way ANOVA shows that there was an effect of professional roles on confidence level with education research of general programs at the $p < .05$ level, $F(2.28, 1.65) = 18.4$, $p = 0$; which is less than $.05$.

Again, results from a one-way ANOVA shows that there was an effect of professional role on confidence level with education research about FEW-Nexus programs at the $p < .05$ level, $F(3.6, 1.14) = 42.8$, $p = 0$; which is less than $.05$. The ANOVA showed the existence of significant confidence level difference for education research about general and FEW-Nexus programs.

Figure 11

Education Research (General & FEW-Nexus programs) Based on Professional Roles/ Positions



Based on the Post-HOC test, Professional role number-1 (Professor), role number-2 (Associate Professor) and role number-3 (Assistant professor) have statistically significant confidence difference

with professional role number 4 (Non-Faculty) for general Education Research. There's also confidence difference between role number- 2 and 3.

Again, based on the Post-HOC test, all professional roles have significant confidence difference with each other with only one exception. Role number-2 and 3 do not have confidence difference between them for FEW-Nexus education research. ([Appendices](#))

Confidence level for education research based on Disciplinary identities:

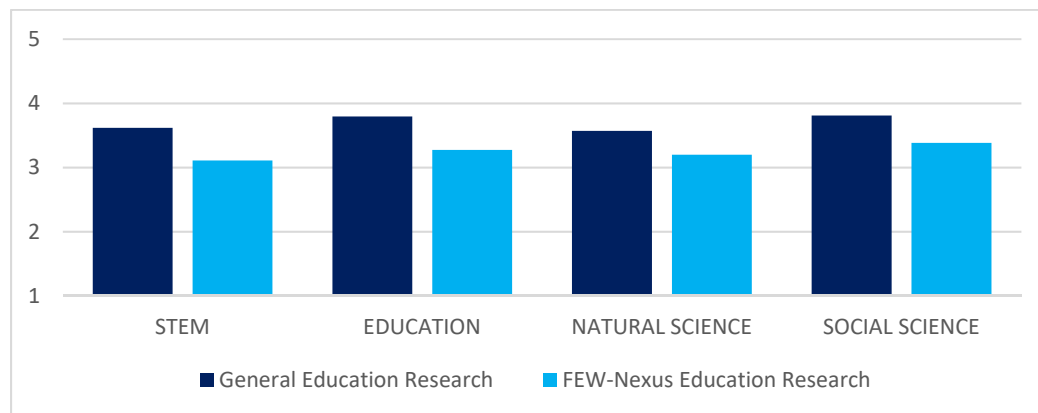
To further understand the difference of confidence level among the participants based on their disciplinary identities, ANOVA and POST-HOC analysis was performed. The ANOVA showed the existence of significant confidence level difference for education research on general and FEW-Nexus programs.

Results from a one-way ANOVA shows that there was an effect of disciplinary identities on confidence level with education research about general programs at the $p < .05$ level, $F (.487, 1.51) = 4.29$, $p = .01$; which is less than .05.

Again, Results from a one-way ANOVA shows that there was an effect of disciplinary identities on confidence level with education research about FEW-Nexus programs at the $p < .05$ level, $F (.438, .803) = 7.27$, $p = .001$; which is less than .05.

Figure 12

Mean confidence in education research based on disciplinary identities:



Agriculture and natural science discipline has statistically significant confidence difference with Education and social science discipline for general education research. STEM discipline has statistically significant confidence difference with Education and social science discipline for FEW-Nexus education research. Agriculture and natural science discipline also has statistically significant confidence difference with social science discipline. ([Appendices](#))

Summary:

Disciplinary identities	Sample size	Coding
STEM	59	1
Education	84	2
Agriculture and natural science	115	3
social science	59	4

Disciplinary identities	General teaching abilities	FEW-Nexus teaching abilities	General education research	FEW-Nexus education research
	2 & 1, 4	Not significant	3 & 2, 4	1 & 2,4 3 & 4

Professional roles	Sample size	Coding
Professor	26	1
Associate Professor	23	2
Assistant professor	35	3
Non-faculty	69	4

General teaching abilities	FEW-Nexus teaching abilities	General education research	FEW-Nexus education research
	2 & 1,3	2 & 3	1 & 2,3
4 & 1,2,3			

Sense of affiliation with the NC-FEW community?

In research question-3, we asked, “To what extent participants feel affiliated and interact with the NC-FEW community? Result showed that participants think interaction ‘To some extent’ with the NC-FEW community helped them in becoming better educator (Mean response- 2.28).

Relationship between FEW-Nexus based teaching abilities and community interaction:

There is a significant positive relationship between FEW-Nexus based teaching abilities (3.43) and the extent of interaction (2.28) between FEW-Nexus community that help them becoming better educator, $r(139) = 0.73$; and the p-value is less than .05 which verifies the significance of the relationship. The relationship is signified from regression analysis. So, we can conclude that the interaction between educators helps the educators in a positive way with their FEW-Nexus based teaching abilities ([Table-6](#)).

Table 6

Regression Analysis concerning FEW-Nexus Teaching Abilities and Extent of Interaction

	R Square	Multiple R	N	SD	P Value	df
Interaction Level						
FEW-Nexus Teaching Abilities	.53	.73	141	1.15	.00	139

Participants’ were asked to determine the interaction level that helped them to become a better researcher. Result showed that participants think interaction ‘To some extent’ with the NC-FEW community helped them in becoming better researcher (Mean response- 2.23).

Relationship between FEW-Nexus based education research and community interaction:

Significant positive relationship is found between FEW-Nexus based education research (3.18) and the extent of interaction (2.23) between FEW-Nexus community that help them becoming better

researcher from regression analysis, $r(139) = 0.76$; and the p-value is less than .05 which verifies the significance of the relationship. So, we can conclude that the interaction between educators helps the educators in a positive way with their FEW-Nexus based research. ([Table-7](#)).

Table 7

Regression Analysis concerning FEW-Nexus Education Research and Extent of Interaction

	R Square	Multiple R	N	SD	P Value	df
Interaction Level						
FEW-Nexus Teaching Abilities	.57	.76	141	1.09	.00	139

Participants were then asked to identify different ways of interaction with the community of educators & education researcher that share the same goals, philosophy & values for FEW-Nexus education for boosting their teaching/ instruction and education research. The way of community interaction for FEW-Nexus based teaching is (Mean=2.27) while ways of community interaction for FEW-Nexus based education research is (Mean=2.24) This change is found not significant from the t-test ([Table-8](#)); $t(9) = 0.45$ Which implies that the way of communication for boosting teaching and research abilities are more or less the same.

Table-8

Paired Sample T-Test for Interaction Level concerning Teaching and Research

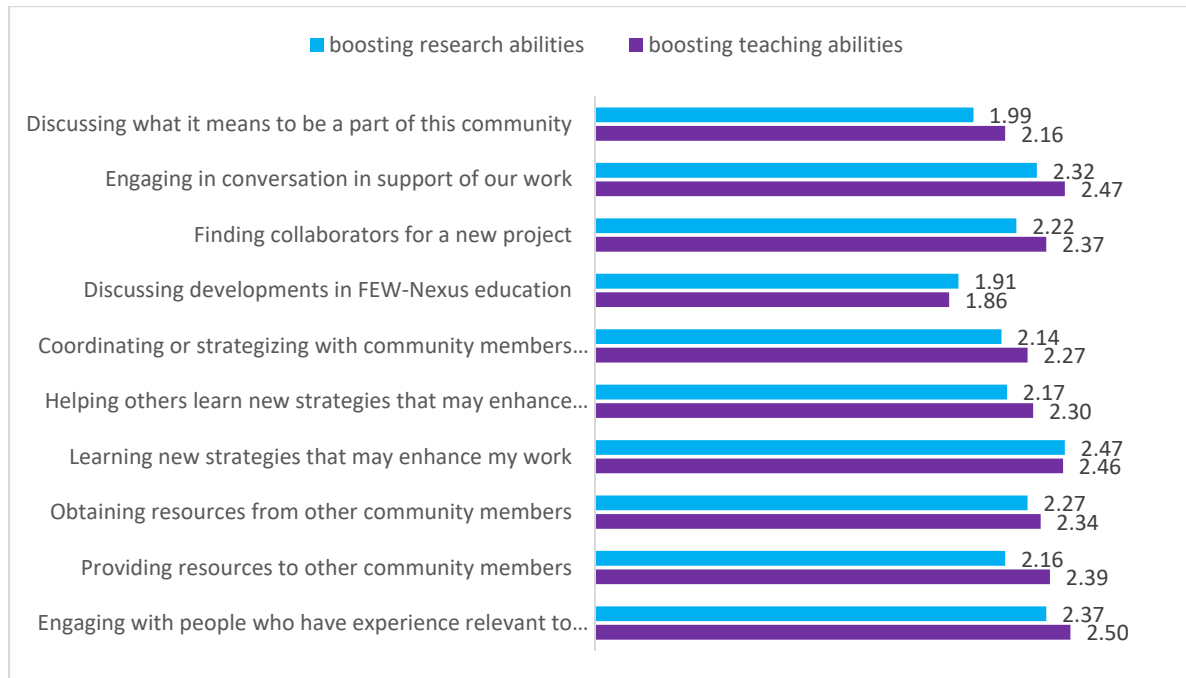
Mean Confidence Level	M	N	SD	t	df
FEW-Nexus Teaching abilities	2.27	10	.948		
FEW-Nexus Education Research	2.24	10	.943	.45	9

Among different ways of interaction ([Figure-13](#)), highest level of interaction occurs while engaging in conversation with people having relevant work experience for enhancing teaching abilities.

And for boosting education research, most interaction happens for learning new strategies. Surprisingly, the interaction level is “only a little” for discussing developments in FEW-Nexus education, which need to be worked on.

Figure 13

Extent of Community Interaction for Boosting Teaching and Research Abilities



Appendices:*ANOVA & POST-HOC for-Teaching abilities confidence based on Professional roles*

		Sum of Squares	df	Mean Square	F	Sig.
General Teaching (Professional Roles)	Between Groups	2.228	3	.743	25.787	.000
	Within Groups	1.152	40	.029		
	Total	3.380	43			
FEW-Nexus Teaching (Professional Roles)	Between Groups	2.346	3	.782	26.670	.000
	Within Groups	1.173	40	.029		
	Total	3.520	43			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) professiona l_roles	(J) professional_roles	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
General Teaching (Professional Roles)	Professor	associate professor	.11985	.07236	.360	-.0741	.3138
		assistant professor	.19376	.07236	.050	-.0002	.3877
		non-faculty	.59904*	.07236	.000	.4051	.7930
	associate professor	Professor	-.11985	.07236	.360	-.3138	.0741
		assistant professor	.07392	.07236	.738	-.1200	.2679
		non-faculty	.47919*	.07236	.000	.2852	.6731
	assistant professor	Professor	-.19376	.07236	.050	-.3877	.0002
		associate professor	-.07392	.07236	.738	-.2679	.1200
		non-faculty	.40528*	.07236	.000	.2113	.5992
	non-faculty	Professor	-.59904*	.07236	.000	-.7930	-.4051
		associate professor	-.47919*	.07236	.000	-.6731	-.2852

		assistant professor	-.40528*	.07236	.000	-.5992	-.2113
FEW-Nexus Teaching (Professional Roles)	Professor	associate professor	-.42105*	.07302	.000	-.6168	-.2253
		assistant professor	-.18809	.07302	.064	-.3838	.0076
		non-faculty	.20412*	.07302	.038	.0084	.3998
	associate professor	Professor	.42105*	.07302	.000	.2253	.6168
		assistant professor	.23296*	.07302	.014	.0372	.4287
		non-faculty	.62517*	.07302	.000	.4294	.8209
	assistant professor	Professor	.18809	.07302	.064	-.0076	.3838
		associate professor	-.23296*	.07302	.014	-.4287	-.0372
		non-faculty	.39220*	.07302	.000	.1965	.5879
	non-faculty Professor		-.20412*	.07302	.038	-.3998	-.0084
		associate professor	-.62517*	.07302	.000	-.8209	-.4294
		assistant professor	-.39220*	.07302	.000	-.5879	-.1965

*. The mean difference is significant at the 0.05 level.

ANOVA POST-HOC for-Education Research confidence based on Professional roles

		Sum of Squares	df	Mean Square	F	Sig.
General Education Research (Professional Roles)	Between Groups	2.286	3	.762	18.420	.000
	Within Groups	1.655	40	.041		
	Total	3.940	43			
FEW Nexus Education Research (Professional Roles)	Between Groups	3.665	3	1.222	42.807	.000
	Within Groups	1.141	40	.029		
	Total	4.806	43			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) professiona l_roles	(J) professional_roles	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
General	Professor	associate professor	-.08182	.08672	.782	-.3143	.1506

Education		assistant professor	.17792	.08672	.187	-.0545	.4104
Research		non-faculty	.51166*	.08672	.000	.2792	.7441
(Professional Roles)	associate professor	Professor	.08182	.08672	.782	-.1506	.3143
		assistant professor	.25974*	.08672	.023	.0273	.4922
		non-faculty	.59348*	.08672	.000	.3610	.8259
	assistant professor	Professor	-.17792	.08672	.187	-.4104	.0545
		associate professor	-.25974*	.08672	.023	-.4922	-.0273
		non-faculty	.33374*	.08672	.002	.1013	.5662
	non-faculty	Professor	-.51166*	.08672	.000	-.7441	-.2792
		associate professor	-.59348*	.08672	.000	-.8259	-.3610
		assistant professor	-.33374*	.08672	.002	-.5662	-.1013
PFR	Professor	associate professor	-.47677*	.07203	.000	-.6698	-.2837
		assistant professor	-.32273*	.07203	.000	-.5158	-.1297
		non-faculty	.26861*	.07203	.003	.0755	.4617
	associate professor	Professor	.47677*	.07203	.000	.2837	.6698
		assistant professor	.15404	.07203	.159	-.0390	.3471
		non-faculty	.74538*	.07203	.000	.5523	.9385
	assistant professor	Professor	.32273*	.07203	.000	.1297	.5158
		associate professor	-.15404	.07203	.159	-.3471	.0390
		non-faculty	.59134*	.07203	.000	.3983	.7844
non-faculty	Professor	-.26861*	.07203	.003	-.4617	-.0755	
	associate professor	-.74538*	.07203	.000	-.9385	-.5523	
	assistant professor	-.59134*	.07203	.000	-.7844	-.3983	

*. The mean difference is significant at the 0.05 level.

ANOVA & POST HOC for Disciplinary Identities:

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) DISCIPLINE	(J) DISCIPLINE	Mean	Std. Error	Sig.	95% Confidence Interval	
			Difference (I-J)			Lower Bound	Upper Bound
General Research	STEM	Education	-.17701	.08291	.160	-.3992	.0452
		Agriculture & Natural Sciences	.04659	.08291	.943	-.1756	.2688
		Social Science	-.19169	.08291	.112	-.4139	.0305

	Education	STEM	.17701	.08291	.160	-.0452	.3992
		Agriculture & Natural Sciences	.22360*	.08291	.048	.0014	.4458
		Social Science	-.01468	.08291	.998	-.2369	.2075
	Agriculture & Natural Sciences	STEM	-.04659	.08291	.943	-.2688	.1756
	Natural Sciences	Education	-.22360*	.08291	.048	-.4458	-.0014
		Social Science	-.23828*	.08291	.031	-.4605	-.0161
	Social Science	STEM	.19169	.08291	.112	-.0305	.4139
		Education	.01468	.08291	.998	-.2075	.2369
		Agriculture & Natural Sciences	.23828*	.08291	.031	.0161	.4605
FEW-Nexus Research	STEM	Education	-.16248*	.06042	.049	-.3244	-.0005
		Agriculture & Natural Sciences	-.08955	.06042	.457	-.2515	.0724
		Social Science	-.27232*	.06042	.000	-.4343	-.1104
	Education	STEM	.16248*	.06042	.049	.0005	.3244
		Agriculture & Natural Sciences	.07293	.06042	.626	-.0890	.2349
		Social Science	-.10985	.06042	.280	-.2718	.0521
	Agriculture & Natural Sciences	STEM	.08955	.06042	.457	-.0724	.2515
	Natural Sciences	Education	-.07293	.06042	.626	-.2349	.0890
		Social Science	-.18278*	.06042	.022	-.3447	-.0208
	Social Science	STEM	.27232*	.06042	.000	.1104	.4343
		Education	.10985	.06042	.280	-.0521	.2718
		Agriculture & Natural Sciences	.18278*	.06042	.022	.0208	.3447
General Teaching	STEM	Education	-.20888*	.06889	.021	-.3935	-.0242
		Agriculture & Natural Sciences	-.05040	.06889	.884	-.2351	.1343
		Social Science	-.01573	.06889	.996	-.2004	.1689
	Education	STEM	.20888*	.06889	.021	.0242	.3935

		Agriculture & Natural Sciences	.15848	.06889	.115	-.0262	.3431
		Social Science	.19315*	.06889	.037	.0085	.3778
	Agriculture & Natural Sciences	STEM	.05040	.06889	.884	-.1343	.2351
	Natural Sciences	Education	-.15848	.06889	.115	-.3431	.0262
	STEM	Social Science	.03466	.06889	.958	-.1500	.2193
	Social Science	STEM	.01573	.06889	.996	-.1689	.2004
		Education	-.19315*	.06889	.037	-.3778	-.0085
		Agriculture & Natural Sciences	-.03466	.06889	.958	-.2193	.1500
FEW-Nexus Teaching	STEM	Education	-.10182	.06437	.400	-.2744	.0707
		Agriculture & Natural Sciences	-.10079	.06437	.409	-.2733	.0717
		Social Science	.02237	.06437	.985	-.1502	.1949
	Education	STEM	.10182	.06437	.400	-.0707	.2744
		Agriculture & Natural Sciences	.00103	.06437	1.000	-.1715	.1736
		Social Science	.12420	.06437	.232	-.0483	.2967
	Agriculture & Natural Sciences	STEM	.10079	.06437	.409	-.0717	.2733
	Natural Sciences	Education	-.00103	.06437	1.000	-.1736	.1715
	STEM	Social Science	.12316	.06437	.239	-.0494	.2957
	Social Science	STEM	-.02237	.06437	.985	-.1949	.1502
		Education	-.12420	.06437	.232	-.2967	.0483
		Agriculture & Natural Sciences	-.12316	.06437	.239	-.2957	.0494

*. The mean difference is significant at the 0.05 level.