The R&D of UN 2030 Sustainable Development Model With AI-Powered Innovation Management to Promote Environmental Literacy and Workforce on the Human-Computer Frontier (Phase I)

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This paper highlights the United Nation 2030 Sustainable Development Goals (UN2030-SDG) to address educational needs, professional development, economic growth, and environmental complexities. The UN2030-SDG project builds on five environmental grants which were funded by the National Science Foundation and the Environmental Protection Agency. The project team adopts an innovation-management approach to transfer technology and knowledge derived from prior grants, incorporates artificial intelligence (AI), blockchain, machine learning, and metaverse (collectively as "disruptive technologies") to support the research and development (R&D) of four AI-powered interventions/programs: (1) e-Conference and (2) e-Workshop for high school educators; and (3) e-Academy and (4) e-Externship for high school students. For Phase-I, the project team expands cross-sectored partnerships, collaborates with cross-industry professionals, leverages existing technological infrastructure, and shares institutional resources and professional expertise to design, develop, and pilot test the program efficacy. The proposed UN2030-SDG model is intended for expanding the education-career capacity by preparing future workforce with interdisciplinary knowledge, transferrable skills, and AI-competency to solve global complexities innovatively on the human-computer frontier.

Keywords: sustainable development, innovation management, ecosystems, & disruptive technologies

INTRODUCTION

Problem & Need Statements

Our world is facing unparalleled challenges, and environmental detractors that pollute the quality of air, water, and land. These global societal complexities ultimately affect our lives and future generations (Transforming Our world, n.d.). World leaders and policymakers are searching for sustainable solutions for water, carbon, and infrastructure resilience to achieve the United Nations' (UN) *2030 Agenda of Sustainable Development Goals (SDGs),* as shown below (**Figure 1**). The National Science Foundation (NSF) and *Environmental Protection Agency (EPA)* urge leaders, grantees, practitioners, researchers, educators, and environmentally conscious individuals to act when our nation is at the intersection of clean energy development and biodiversity conservation to address improper e-waste, soil degradation, natural resource depletion, wildfires, deforestation, pollution, and global warming (NSF, n.d.).

FIGURE 1
UN2030 SUSTAINABLE DEVELOPMENT MODEL

Source: United Nations Department of Economic & Social Affairs (n.d.)

Project Goals & Program Objectives

To align with the priorities of NSF, EPA, and the UN 2030 SDGs, the University of Central Oklahoma (UCO) proposed the following Artificial-Intelligence (AI)-powered interventions/programs (Table 1) to address educational, economic, and environmental complexities. The goal of this study is to generate new knowledge of how to promote environmental literacy and prepare an equitable workforce for solving societal inequity and global complexities. The proposed programs aim to achieve program objectives with supporting activities to integrate academic research, innovative practices, disruptive technologies, real-world context, rigorous scientific methods, and sustainable ecosystems via AI-powered (1) e-Conference to promote public's environmental literacy, (2) e-Workshop to support high school teachers with training to enhance professional currency for incorporating UN2030-SDG topics into their Science, Technology, Engineering, and Math (STEM) curricula and teaching with disruptive technologies to students; (3) e-Academy to promote career exploration; and (4) e-Externship with job-shadowing, knowledge-acquisition, and skill-development venues to support students in pursuing environmental career-education pathways.

TABLE 1
PROGRAM OBJECTIVES TO ALIGN WITH THE UN 2030 SDG

Intervention	Modality	Objective to Promote	Supporting Activities
1. e-Conference	Hybrid	Awareness & Literacy	Innovative Practices & Solutions for Society
2. e-Workshop	Hybrid	Innovative Pedagogy	Teacher Trainings to Incorporate UN2030-SDG
3. e-Academy	Hybrid	Career Interest	Out-of-school Bridge Program to explore careers
4. e-Externship	Virtual	KSA & Innovations	Grass-root Services for Communities with needs

Multi-Modality of AI-Powered Interventions via Information Communication Technology (ICT)

COVID-19 sped up digital transformation and ICT, such as Zoom, and has shaped a new trend of digital practice to attend virtual school, conference, and/or work from home. While most schools, workplace, and conferences resume in-person attendance in the post-pandemic era, the project team will continue to adopt Zoom to accommodate participants who lack travel budget. Contents of the proposed programs will be delivered with multiple methods ("multi-modality"). Project stakeholders including cross-sector partners, educators, students, cross-industry collaborators (researchers, grantees, practitioners), and policy makers will be engaged in the planning, design, development, implementation and research phases to address UN2030-SDG with sustainable solutions. Benefits of hybrid (in-person attendance on UCO campus plus online resources) and virtual (offsite) include: (1) decreased carbon emissions to cut down travel via cars or planes, (2) affordance due to reduced travel cost, and (3) global accessibility for participants to attend across the state of Oklahoma, region, United States, and continents without location constraint.

Opportunities of Emerging Careers Infused With Disruptive Technologies

The project team adopts the Environmental Forensics and Data Centric lens to engage project stakeholders who address educational, professional, economic, and environmental complexities with innovative solutions. Environmental Forensics, which is an emerging field, involves the analysis of biological materials, addresses various aspects of environmental issues within the legal framework (BCC Research, 2024; Brčeski & Vaseashta, 2021). Environmental Forensics often adopts scientific methods and disruptive technologies to leverage the computing power and promote emerging career opportunities. This project will adopt disruptive technologies including (1) AI which has a market capital of US $100 billion in 2024 and $500-600 billion by 2030 (U.S. Bureau of Labor Statistics, n.d.); (2) Blockchain which will be worth $176 billion by 2030 (Gartner, n.d.); (3) Data Science which is projected to grow 35% annually (U.S. Bureau of Labor Statistics, 2024); and (4) Metaverse jobs which are projected to grow 37% in the next five years with a projected market of $490.4 billion by 2030 (Statista, n.d.).

The project team incorporates these disruptive technologies into the design of the proposed interventions. Ultimately, these AI-powered intervention innovations can provide insights on how to build an equitable, diverse, and innovative workforce who will become future data scientists, AI technologists, robotic engineers, and quantum-computing mathematicians to address educational, societal, economic, and environmental complexities with innovative solutions. Specifically, the project team engages the local and global communities of policy makers, grantees, transdisciplinary researchers, practitioners, educators, homeschooling parents, students, e-Externship sponsors/mentors, and community leaders ("project stakeholders") to address poverty, quality education, social inequity, water resources, health and well-being, infrastructure, food insecurity, land diversity, climate change, and partnerships (United Nations, n.d.).

Project Timeline

This UN2030-SDG project will be executed in three phases (Table 2): Phase-I (2024) reflects the scope of this paper via an innovation-management process to transfer existing technology and working knowledge from five SDG-relevant grants to support the development of the proposed interventions. Phase II (2025) entails implementation to pilot test the program efficacy of the proposed intervention innovations and disseminate findings on the interventional effects on project stakeholders, local communities, and global society. Phase III (2026 - 2030) will secure federal funding to replicate the UN2030-SDG model and scale the interventions across the state, region, nation, and continents.

TABLE 2
PROJECT PLAN & TIMELINE OF THE AI-POWERED INNOVATION MANAGEMENT

Intervention with Supporting Activities to Achieve Program Objectives	**Assignee**	**Phase**		
		I	**II**	**III**
Project Planning & Expand Partnerships	**PI & Co-PI**	**X**		
Transfer Technology, Knowledge, and Skill to Support the UN2030 SDGs	**PI & Co-PI**	**X**		
Create/Revise Survey Instruments for Data Collection & Analysis	**Researcher**	**X**		
Design & Develop Interventions with Disruptive Technologies	**Partners**	**X**		
Pilot AI-powered Interventions with AI-powered Innovations	**PI & Team**		**X**	
Collect/Analyze Data, **Disseminate Findings & Share with Project Stakeholders.**	**PI & Team**		**X**	
Findings Evaluate Project & Societal Impacts	**PI & Team**		**X**	
Prepare and Submit Grants to NSF & EPA to Replicate UN2030 Model	**PI & Team**			X
Secure External Funding to Scale up Innovations Across the Region and U.S. A.				X
Evaluate Project Impacts & Prepare Formative/Annual & Summative Reports				X
Publication(s) in top-tier journal(s)				X

FOUNDATION & FRAMEWORKS OF AI-POWERED INNOVATION MANAGEMENT

This multi-phase UN2030-SDG project builds upon the success of five prior grants funded by the National Science Foundation (NSF) and Environmental Protection Agency (EPA). The project team adopts an innovation-management approach to transfer technology and knowledge derived from the prior works to support the research and development (R&D) of the proposed to align and support the UN2030-SDG. The proposed AI-powered interventions are built upon the equitable, collaborative, and innovative frameworks. The project team focuses on sustainable innovations to address the education, professional, environmental, and societal challenges by engaging grantees, researchers, practitioners, educators, and policy makers ("project stakeholders") in the strategic planning, development, and implementation phases to leverage existing technological infrastructure, institutional resources, and professional expertise (**Figure 2**).

FIGURE 2
UN2030-SDG MODEL WITH INNOVATION MANAGEMENT

Equitable Framework to Address Diversity, Equity, and Inclusion (DEI) & Community Needs

UCO, which locates in Oklahoma, is an Established Program to Stimulate Competitive Research (EPSCoR) state. Traditionally, EPSCoR states receive less federal funding. Further, UCO, a non-R1 university (primary teaching institutions), received less funding when compared with R1 institutions (primary research institutions with PhD programs). According to the NSF solicitation # 23-617, 19 out of 20 awards went to R1 institutions during the 2013-2023 period (Empowering Broader Academic Capacity and Education, 2023). To broaden and deepen the impacts of UN2030-SDG, UCO proposes to form synergized partnerships with R1and non-R1 universities to serve K-12 schools, communities, and global society with education, professional, environmental, and economic needs.

Further, Oklahoma is the home to 39 federally declared tribes. Native Americans face many challenges to participate in the STEM professions. Deterrents include the lack of funding, resources, and expertise to build the technological infrastructure, support teacher development, and prepare youth for high-paying jobs. According to the U.S. Department of the Interior Bureau of Indian Education, (1) college enrollment dropped by 40% in the last decade (2014-2024), (2) students received 50% less Pell grants than other ethnicities, (3) 16.8% American Indians vs. the national average 35.7% graduated from college, (4) only 0.02% of indigenous populations are represented in STEM careers, and (5) 1 out 4 tribal members lives in poverty (U.S. Bureau of Indian Education, n.d.).

To bridge the educational, professional, social, and economic equity due to underfunding, underrepresentation in STEM fields, unaffordable workforce development, and pay gaps, UCO proposes implementing diversity, equity, and inclusion (DEI) strategy to build an innovative workforce by sharing existing technological infrastructure, institutional resources, and professional expertise. Tribal leaders, educators, partners, and professionals will be engaged to co-design culturally resonant workforce development via rigorous AI-powered STEM curricula to meet their educational, professional, economic, and environmental needs. The project team will target the underserved via three catchments: (1) an annual *EPSCoR Science Conference* (a well-attended event by thousands of K-12 teachers, counselors, and students); (2) Oklahoma STEM Zones (12 Oklahoma counties with prevalent poverty); and (3) Central OK STEM Alliance (schools needing technological and environmental infrastructures). The target population

include high school educators and students who are females, minorities, the disabled, the neurodivergent, and the LGBTQIA2S+ from underperforming schools, reservations, and tribal communities.

Cross-Sector Partnership and Cross-Industry Collaboration to Transform Education

Research shows that partnerships between academia and industry can improve STEM and literacy to solve challenges through innovative methods (Patton, 2019; Sotiriou, 2017). Thus, UCO expands cross-sector partnerships such as government, industry, non-governmental organizations, and universities (*GINOTU*) to promote authentic learning of real-world context, transform the current K-12 education, and bridge skill gaps. UCO will collaborate with cross-industry professionals representing GINOTU and engage diverse stakeholders (e.g., grantees, educators, practitioners, industry leaders, and policy makers). Examples of cross-sector partnering institutions include Oklahoma State Department of Environmental Quality (DEQ), Oklahoma State Bureau of Investigation (OSBI), NSF, Devon (a Fortune 500 Company in Oil & Gas sector), Paycom (another Fortune 500 Company in Software sector with green technology), OKC Sustainability Office (OKCS), and UCO Sustainability Center.

Zoom will be used to engage (1) 35 cross-industry professionals, transdisciplinary researchers, NSF and EPA grantees who represent GINOTU partnering institutions, (2) 10 tribal leaders from Native Nations (e.g., Choctaw, Chickasaw, Kiowa), and (3) 40 educators in project planning and program design for 450 high school students. The UN2030-SDG will focus on sustainability, renewable energy, clean water technologies, and infrastructure development to address educational, professional, and economic needs of local community and global society. Attentive stakeholders and enthusiastic individuals from the local communities will be engaged to discover transformative models for educating our youth and the public about environmental projects to address global-societal complexities with innovative solutions and create a more environmentally sustainable world.

Innovation Management via Knowledge & Technology Transfer From Five Prior Grants

The project team adopts an innovation-management approach to maximize the return of federal funding by building the proposed UN2030-SDG project onto the success of the following environmental grants. Technology and knowledge transfers occur to leverage existing technological infrastructures and insights derived these prior grants to expand the education-research capacities and support the R&D of the proposed.

A Socially Sustainable Solutions for Water, Carbon, & Infrastructure in Oklahoma (S3OK)

This NSF-funded *S3OK* grant (Award # 1946093) was led by the University of Oklahoma (a R1 institution). This grant engaged data scientists, interdisciplinary researchers, practitioners, and policy makers to identify sustainable solutions for the resilience of ecosystems over the 2020-2023 period. The project also focused on the following themes: (1) weather patterns and their effects on water availability; (2) carbon dynamics related to land management and climate change; (3) water reuse and sustainability, (e.g., water treatment from oil and gas extraction); and (4) infrastructure challenges (e.g., wildfires, and drought (S3OK, n.d.).

An Educational Program on Awareness, Sustainability, & Service in Water (EdPASS-H2O)

This EPA-funded *EdPass-H2O* grant (Award # 84034501) was led by the East Central University in Oklahoma (non-R1). *EdPass-H2O* grant was part of EPA's Innovative Water Infrastructure Workforce Development. The *EdPass-H2O* project was led by. This project focused on environmental sustainability, particularly related to water resources over the 2020-2023 period. EdPass-H2O had a pre-apprenticeship program designed to prepare students for careers in water and wastewater management (EdPass-H2O, n.d.).

A State Grant to Promote Responsible Food Production & Consumption (Ayers Food Pantry)

This DEQ grant was led by UCO (non-R1) to promote responsible food production and consumption by reducing food waste over the 2020-2023 period. Surplus food from UCO's main dining facility, Ayers Kitchen, was packaged and meals were available to students, faculty, and staff with food insecurity. Any unclaimed meals are composted to promote sustainable practices on UCO campus (DEQ, n.d.).

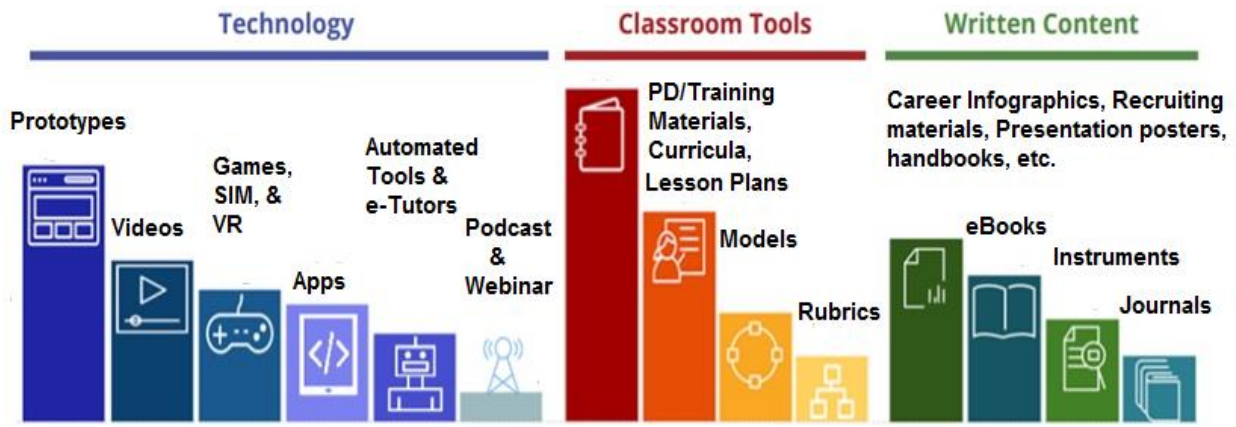
Environmental Forensics Grant for Girls to Promote Gender Equity (EF4Girls)

This NSF-funded *EF4Girls* grant (Award # #1758975) was led by UCO. This out-of-school summer bridge program provided high school students with career-exploration, job- shadowing, mentoring, knowledge-acquisition, and skill-development venues over the 2018-2022 period. The focus was on Environmental Forensics which engaged students to investigate pollutants that affected land biodiversity, air quality, and water resources. To develop next generation leaders, former EF4Girls participants, who graduated from college and work for Fortune 500 Companies based in Oklahoma (e.g., Boeing, Devon, Paycom), were invited to share their work experiences and the Corporate Social Responsibility (CSR) and Environmental, Social, and Governance (ESG) practices of their employers to benefit global society (EF4Girls, n.d.).

Supercomputer to Extend Technological Infrastructure & Expand Research Capacity (Buddy)

This NSF-funded grant (award #**1429702**) was led by UCO to promote and support research at non-R1 institutions over the 2015-2017 period. This project, which was developed by the *Center for Research and Education in Interdisciplinary Computation*, aimed to leverage the established network of K-12, 2- and 4-year colleges for collaborations and facilitated the research-education integration through training opportunities for educators and researchers. The award included a supercomputer, which was named after UCO's mascot "Buddy Broncho," to serve the UCO community and researchers across Oklahoma. The project acquired a computing resource to enable research efforts with interdisciplinary projects including ecological modeling, bioinformatics, and the spread of disease (Buddy, n.d.). Innovative portfolio of intellectual properties derived from five aforementioned grants as well as new products/outputs to be derived from this newly proposed UN2030-SDG project will reside on this supercomputer (**Figure 3**).

FIGURE 3
TECHNOLOGY TRANSFER FROM PRIOR GRANTS TO THE UN2030-SDG PROJECT



Innovative portfolios, which have the potential for patents, are organized in three categories: (1) **Technology** pertains to existing intellectual properties (IP) from prior grants and new IP innovations (e.g., mobile apps to monitor air and water quality tracking, interactive simulations, and digital mapping tools) to be enhanced with disruptive technologies (e.g., AI, blockchain, machine learning, metaverse); (2) **Classroom Tools** are educational resources for teachers and students which include lesson plans, rubrics, and intelligence platform such as Code.org (a nonprofit) to customize learning modules based on students' needs and competency levels; and (3) **Written Content** category includes outcomes, artifacts by participants (e.g., career infographics, project highlights, and NSF International Video Showcase), and research outputs/products (e.g., conference proceedings, peer-reviewed journals, posters from Oklahoma Research Day or Undergraduate Research Council by the project team to promote SDG initiatives.

Transferrable Skills, Visibility, & Leadership

These proposed interventions aim to foster 21st-century skills which can be transferred into domains of emerging careers. These soft skills include computational and systematic thinking, critical problem solving, analytical skills, AI competency, environmental literacy, data scientific inquiry, logical reasoning, evidence-based decision-making, creativity, innovation, project management, collaboration, entrepreneurship, public speaking/presentation, and leadership (United Nations, n.d.). Awards and recognition of outstanding projects by educators, students, and externs will be recognized on the project website. Former participants will be invited to share their experience and success in implementing sustainable solutions with new attendees. Focusing on real-world applications, hands-on learning, job shadowing, skill acquisition, and mentorship can enhance students' SDG knowledge and skills to become future leaders in sustainability.

DEVELOPMENT OF AI-POWERED INTERVETION INNOVATIONS

Sections below describe how the synergized GINOTU partnership and collaboration will support the proposed AI-powered interventions to align with the UN2030-SDG. These proposed interventions are intended for capacity building on implementing SDG-related initiatives in various sectors. Successful SDG initiatives or sustainable business practices to address (1) the educational, professional, and economic needs of the underserved communities and (2) the environmental protection and sustainability by promoting public environmental literacy, professional currency and student preparation for participating in the highly competitive workforce (United Nations, n.d.).

Intervention # 1 AI-Powered e-Conference to Promote Environmental Literacy

This free e-*Conference, which* functions as a feasible precursor to enhance public awareness of the UN-2030 SDG agenda and environmental literacy, aims to drive actions by the sustainably minded, educators, and policy makers relating to the local, regional, and global SDG initiatives. Cross-industry professionals representing GINOTU will share their expertise, career trends, and disruptive technologies. Attendees will gain real-world insight on how inter-disciplinary knowledge and disruptive technologies can be applied to solve societal issues, educational, and environmental complexities (e.g., poverty, food insecurity, equity, economic growth, water resources, land diversity, and global warming) with innovative solutions.

Pre-Conference Planning & Event Promotion

Cross-industry professionals, who represent the GINOTU partnering institutions, are invited to brainstorm e-Conference sessions. Further, these professionals will present, facilitate, and interact with the public, form network, and collaborate on community-based, SDG-related projects. Social media platforms (Meta, LinkedIn, and TikTok), speaker profiles, teaser videos, and infographics about SDGs will be used to enhance visibility of the AI-powered e-Conference.

Structure of the AI-Powered e-Conference

This free e-Conference (**Table 3**) can be attended in person or via Zoom. Zoom, a widely adopted platform during the pandemic, has proven an affordable venue to broaden participation by overcoming geographic location constraints and the lack of travel funds. The opening session will include a keynote speaker, who is an expert on global environmental challenges, will provide an overview of the UN 2030 SDGs and the urgency of addressing these goals related to water, land, and air pollution. Cross-industry professionals, policymakers, and practitioners representing GINOTU partnering institutions will also present innovative tools, sustainable solutions, and best practices of CSR and ESG by government agencies, multinational corporations, NGOs, and nonprofits. Industry examples include Amazon, Apple, Microsoft, IKEA, Tesla, and Disney that are part of the growing movement to reduce their carbon footprint via renewable energy, green technology, and AI-powered solutions to improve efficiency and sustainable supply chain practices.

TABLE 3
AGENDAOF THE AI-POWERED E-CONFERENCE

Time	Thematic Session	Application	Presenter	Partnership
9 am	Environmental Complexity & Sustainability	UN-2030 SDG & Global Impacts	Wagner	EPSCoR [1]
10 am		Climate Change	Baker	OKCS[2]
11 am	Water Resource	Desalination & Water Filtration	Roberson	EPA Grantee[3]
Noon	**Breakout Sessions e**xplore how pollution impacts local and global ecosystems, innovative solutions to address community needs, & share challenges educators face in teaching environmental issues.			
1 pm	Land Management	Bioinfomatics: Endangered Species	Williams	UCO & EQ[4]
2 pm	Air Pollution & Green Tech	Environmental Analytics GHG	Bowman, Chae, etc.	OKCS
3-4	Societal Impacts	CSR & ESG		SAS & UCO

1. Dr Wagner, PI of the S3OK grant & EPSCoR Director; 2. Baker, a senior planner at the OKC Office of Sustainability; 3. Williams, retired from Dept of Environmental Quality; 4. Roberson, EPA grantee

Technological Tools for Engaging e-Conference Participants

Professionals will facilitate the breakout sessions to engage attendees in open dialogs, pitch ideas/projects aligned with SDGs, and receive feedback. The project team will record live presentations. Live Q&A and polls will be used to encourage real-time interaction with global audiences. The project team will also set up virtual booths for participants to explore SDG-related projects and innovations. Virtual networking sessions are designed to foster partnerships across sectors. To foster professional networking, participants can scan the QR codes off the digital flyers to access presenters' LinkedIn profiles and join the professional network.

Post-Conference Evaluation & Callable Action

The E-Conference will end with a call for action by encouraging participants to engage in SDG-related initiatives and contribute in their own ways. Post-event content (e.g., recorded sessions, summaries, and key takeaways) will be available for a broader audience who cannot attend the live event. The project team will also analyze e-Conference data to create follow-up content for the e-Workshop to keep the open-dialog going and resources are also available for attendees to take actions after e-Conference (e.g., adopting sustainable practices, forming professional network, joining SDG-aligned coalitions, grassroot initiates).

Intervention # 2 AI-Powered e-Workshop for Educators to Model UN2030-SDG

This free e-Workshop, which will train educators how to incorporate UN2030-SDG modules into their age-appropriate STEM curricula and teach environmental sustainability to high school students with innovative technologies. e-Workshop and supporting activities are designed to achieve program objectives by: (1) raising awareness among teachers about the impact of pollution on air, land, and water ecosystems; (2) equipping teachers with innovative solutions and teaching methodologies that align with SDGs; (3) providing hands-on tools, resources, and lesson plans to integrate into their classrooms; and (4) fostering collaboration between educators and professionals to create community-driven initiatives. The ultimate goal is for teachers to maintain professional currency with training on how to teach vigorous environmental contents to inspire their students and communities to act.

Pre-Workshop Planning & Event Promotion

Cross-industry professionals, who represent the GINOTU partnering institutions, are invited to brainstorm e-Workshop training sessions and teaching modules. These professionals will also present, facilitate, and interact with the public, form network, and collaborate on community-based SDG-related

projects. Social media platforms and facilitator profiles will be used to enhance visibility of the e-Workshop.

e-Workshop Structure & Adoption of a Case Study With Storyboard and Real-World Scenarios

This five-day workshop is designed to empower teachers in becoming champions of environmental sustainability within their schools and communities. Teachers, who can play a significant role in promoting UN2030-SDG, will be trained on how to help students connect classroom materials to real-world problems. The training modules (**Table 4, below**) are organized around environmental themes (e.g., water, land, air management, societal implications, and innovative solutions).

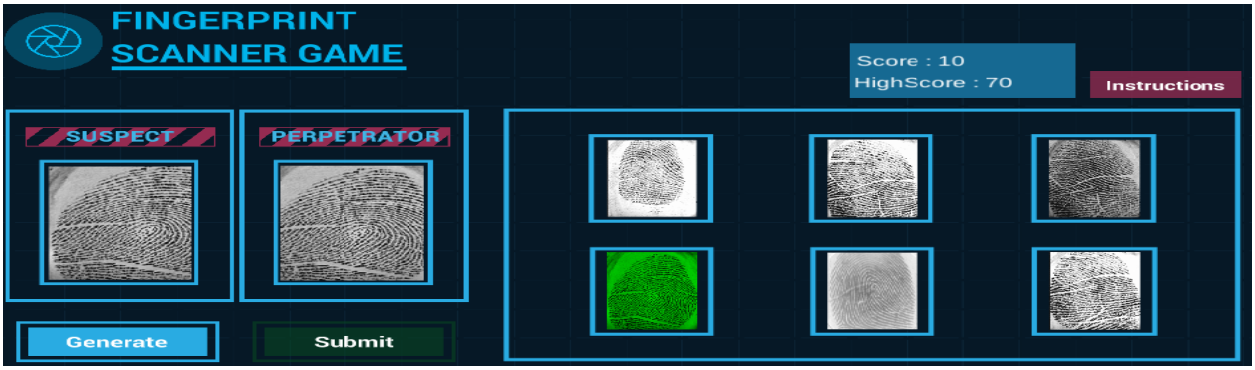
TABLE 4
AGENDA OF THE AI-POWERED E-WORKSHOP TO PROMOTE UN2030-SDG

Daily Training Module	Facilitator & Affiliation	Data-centric Topics	Technology
1. Water Management	Dr. Robertson, EPA Grantee	Recycle Wastewater	Mobile Apps
2. Land Management	Williams, DEQ & Devon	e-Waste & Robotic Tools	Drones, GIS, & GPS
3. Air Management	Bowman, OKCS	Sustainability Mindset	Carbon Footprint: GHG
4. Data Science	Dr. Chae, UCO	Environmental Analytics	SAS Studio
5. AI & Impacts	Dr. Cheng, UCO	Computer Ethics	Open AI & ML

e-Workshop Day 1 (Water-Management Training Module). This module builds on the prior *EdPASS-H2O* grant to promote awareness, sustainability, career, and service in the water/wastewater utility sector. Training module is designed for educators to acquire knowledge of wastewater management and career opportunities in the drinking water and wastewater utility sector. Teachers will also learn how to use environmental apps and innovative tools (e.g., water quality monitoring kits) to measure local water health. A case study is also adopted to deepen teacher understanding of water scarcity, pollution, and innovative solutions for clean water access. The case study also provides content for educators to immerse students in hands-on activities to (1) monitor local water sources, (2) gather data on pollutants, and (3) test the water quality to ensure public health and safety. Teachers will also work in teams to brainstorm the design of water conservation campaigns or school-based projects.

e-Workshop Day 2 (Land-Management Training Module & Environmental Forensics). This module, which builds onto the prior *S3OK* grant, aims to increase environmental literacy and awareness of land degradation, deforestation, soil contamination. First, teachers will use AI-powered agriculture tools to detect land pollution and biodiversity. Teachers will learn mor about waste management solutions (e.g., recycling, sustainable agriculture, and reforestation). Next, teachers will also be exposed to *Environmental Forensics* and Biometrics tools to investigate e-Waste (e.g., illegal dumping of computers with harmful chemicals such as mercury). For example, teachers will perform hands-on activity to search for fingerprints off the abandoned PC/keyboards and then use the Search Engine (**Figure 4**) to look for matches in the criminal database like the Automated Fingerprints Information Systems (AFIS) to find the suspect(s).

FIGURE 4
SEARCH ENGINE WITH AI-BIOMETRICS & MACHINE LEARNING



Further, teachers will use other automated tools including a drone which is type of " unmanned aerial vehicle (UAV) without a human pilot onboard. A drone combined with Geographic Information System (GIS) and Global Positioning System (GPS) can be controlled remotely and used in conjunction with a FARO system to process polluted sites when the toxicity is too high for humans. Day-3 will end with a collaborative session for teachers working in groups to co-design land conservation lessons or grassroot initiatives/programs (e.g., community clean-up initiatives, recycling programs, and composting).

e-Workshop Day 3 (Air-Management Training Module). This module builds on the prior *EF4Girls* grant to promote clean energy with green technology, reduce carbon dioxide, and monitor Greenhouse Gas (GHG) inventory. Educators will be trained with AI-powered air-quality training, UCO will collaborate with aforementioned partners to formulate innovative solutions for improving air quality. Sustainable solutions include renewable energy (e.g., wind, solar panel), electric vehicles (EV), and carbon capture technologies. Workshop facilitators will highlight successful government and community initiatives. Teachers will continue to work in group activities to co-design lesson plans with classroom activities to engage students in using air quality sensors or simulations to teach students about air pollution sources and solutions. Teachers will also be trained on how to incorporate innovative pedagogy to help students connect what they learn in school to solve real-world problems, fulfill CSR, comply with ESG, and mitigate climate change.

e-Workshop Day 4 (Innovative Solutions With Data Science & Environmental Analytics). Day-4 training builds onto prior *EF4Girls* and *Ayers Food Pantry* projects. Teachers will have access to an analytical platform, SAS LLC (a for profit) and an open-source platform, Code.org (a nonprofit) to access pre-designed lesson plans and innovative resources for addressing air, land, and water pollution solutions. Teachers will use innovative apps and tools designed to (1) track pollution levels (e.g., air quality monitoring apps); (2) facilitate project-based learning (e.g., *Google Earth* for environmental mapping); and (3) engage students in an immersive environment where students can role play with avatars as environmentalists or data scientists to solve pollution in a fun and engaging way.

e-Workshop Day 5 (Grantsmanship With AI & Society Implications). This module introduces teachers to Large Language Model (e.g., Open-AI ChatGPT, Google Bard, Microsoft Copilot), machine learning algorithm. Teachers will use ChatGPT to brainstorm an outline to write a grant to seek funding for conducting environmental projects in their classrooms or serve their local communities with needs. Teachers will also share their strategies for integrating air, land, and water pollution solutions into their STEM curricula. Teachers are challenged to think innovatively about how to engage students in solving pollution issues via digital tools, gamification, or project-based learning. Teachers will present their design and action plans for implementing school-wide or community-driven SDG initiatives, such as tree-planting campaigns, clean-up drives, or student science fairs on pollution solutions. Teachers will gain access to these innovative tools and resources to customize teaching modules for their classrooms to accommodate

students' educational needs based on their competency levels. Trainers will share more resources for continued learning to drive long-term actions and promote the SDGs in education.

Post-Workshop Support, Teacher Network & Community Engagement

To help teachers implement their lesson plans and SDG initiatives, the project team will provide teachers with technical support via AI-automated Chatbot, teacher network, mentorship, and online forums. The teacher network will function as a platform for participants to continue sharing best practices, lesson plans, and project outcomes. Teachers will also be connected to community partnerships by engaging (1) local businesses, NGOs, and government agencies in supporting school-based SDG projects; and (2) students in cross-school projects to foster collaborations between schools by creating inter-school competitions on pollution solutions for larger impact initiatives. The project team will also promote successful stories or grassroot initiatives through local media, educational platforms, and social media to inspire other educators.

Intervention AI-Powered e-Academy to Broaden Participation by the Underserved

This out-of-school bridge summer program is designed to encourage high school students exploring environment-related careers by (1) introducing the UN2030-SDG; (2) educating students on global and local pollution challenges; (3) teaching students about innovative solutions and encourage them to develop their own; (4) promoting responsible food consumption and sustainable living practices; and (5) equipping students to be SDG ambassadors in their schools and communities. This free AI-powered summer program also aims to broaden STEM participation by the underserved (e.g., girls, homeschool students, and the native Americans, and the socio-economically disadvantaged), is designed with disruptive technologies to broaden career awareness of and interest in environmental-related careers (e.g., Environmental Sustainability, Bioinformatics, Gene Editing, and Environmental Forensics). Career-exploration venues include site visits, job shadowing and interaction with professionals to promote awareness and interests in the immense environmental career opportunities Professionals representing GINOTU partnering entities are engaged to co-design the programming with age-appropriate content, real-world context and innovations. Trained high school teachers will work alongside professionals as e-Academy co-facilitators.

Pre-Academy Planning & Event Promotion

Educators (prior e-Workshop attendees) and cross-industry professionals who represent the GINOTU partnering institutions and educators, are invited to brainstorm e-Academy training sessions and teaching modules. These professionals will also present, facilitate, and interact with the general public, form network, and collaborate on community-based SDG-related projects. Social media platforms, facilitator profiles, and infographics about SDGs will be used to enhance visibility of the AI-powered e-Academy.

e-Academy Structure

The five-day agenda (**Table 5**), which outlines the structure of the program, focuses on innovative solutions for air, land, and water pollution as well as responsible food consumption. Daily agenda above) are broken into four tracks to explore AI-powered solutions and practice with innovative tools. Environmental topics will be presented by professionals representing GINOTU partnering institutions and project stakeholders in morning (**AM**) sessions, while engaging students with hands-on activities to perform experiments in the *Innovation Lab* to conduct experiments using disruptive technologies in afternoon (**PM**) sessions.

TABLE 5
AGENDA OF THE AI-POWERED E-ACADEMY

Time	Day 1: UN2030 SDG	Day2: Water	Day3: Land	Day4: Air	Day5: Impact
AM	UN2030 Overview & Environmental Databases	Water-related Solutions	AI-Agriculture & e-Waste	Climate Solution	AI Biases, & Ethics
PM	**Innovative Lab with Analytics, Open-AI, Metaverse, Blockchain, Metaverse, & Machine Learning**				
	Environmental Forensics, Data Science, & e-Waste	Ocean Pollution, Drove, GIS, & GPS, & Sustainable Solutions		GHG, CSR, & ESG	Career Infographics
Presenters representing GINOTU Partners, grantees, practitioners, educators, and project stakeholders: Day-1: Drs. Wagner (NSF-S3OK), & Cheng (NSF-EF4Girls); Day-2: Drs. Roberson (EPA-EdPASS-H2O); Day-3: Drs. Bowman & Williams (DEQ-Ayers Food Pantry); Day-4: (Drs. Chae); Day-5: Drs. Cheng & Qian (NSF-Buddy).					

e-Academy Day-1 Sessions (UN2030-SDG Overview & Environmental Challenges). Day-1 AM sessions introduce students to UN 2030 SDGs, pollution, and sustainability pertaining to the air, land, water pollution, and responsible consumption. Presenters will explain the connection between human activities and environmental degradation using videos, infographics, etc. Day-1 PM sessions are hands-on activities for students to use Open-AI (e.g., Copilot, ChatGPT) to design a database for storing environmental data. Students will learn the difference between Data Science and Environmental Analytics. Students will also work in teams to solve environmental pollution by using *Environmental Forensics* tools to investigate the source of e-Waste (e.g., illegal dumping of computers with harmful chemicals). For example, students will be exposed to Environmental Forensics and Biometrics by role playing as investigators to collect fingerprints from abandoned PC/keyboard and then search for matched fingerprints in AFIS criminal database to trace the source of the contaminant.

e-Academy Day 2 Sessions (Water Resources). Day-2 AM sessions include expert talks by scientists and environmentalists and a field trip to visit a local water treatment facility or a polluted water body (river, lake) to see the impact of pollution firsthand and how technology solves water pollution issues. Professionals will job-shadow how to address water scarcity or purification via low-cost water filtration devices to test the water quality by analyzing the pH, chemical content of local water sources. PM sessions (**Figure 5**) immerse students in a virtual learning environment simulated with real-world scenarios. Students will perform hands-on activities via immersive simulations, gamification, virtual reality (VR), and UAV (e.g., drones). A professional will demonstrate how a drone can be controlled remotely to take photographs, measure a crime scene (e.g., polluted land or water with toxicity). *Educational Benefits of Metaverse & Simulation*: Using metaverse simulated with real-world scenarios can enrich experiential learning experience when re-creating the crime scene is too expensive or impossible (e.g., oil spill with harmful chemical causing ocean pollutions). Research shows that immersive simulation fosters career identity via role playing as STEM professionals to investigate toxic sites and solve environmental pollution.

FIGURE 5
INNOVATIVE TECHNOLOGIES (E.G., METAVERSE, VR, & DRONE WITH GIS/GPS)

e-Academy Day-3 Sessions (Land Diversity & Responsible Food Production/Consumption). AM presenters will share the importance of Sustainable Agriculture, food production, and responsible food Consumption by highlighting the impacts of sustainable farming, reducing food waste, and eating responsibly (plant-based diets, reducing meat consumption). PM sessions continue to immerse students in metaverse with VR to role plan as (1) scientists who facilitate a virtual fieldtrip to a sustainable farm; (2) farmers who grow organic food; (3) manufacturers who are committed to zero-waste initiatives with responsible food production; (4) nutritionists who recommend viable food choices that are healthier and environmentally friendly since manufactures use more water to process meat); (5) practitioners who adopt sustainable practices to reduce food waste in local communities; and (6) volunteers who address food insecurity by feeding the hunger in local community with food surplus from school cafeterias or near-by restaurants.

e-Academy Day-4 Sessions (Air Pollution & Green Technologies). For AM sessions, professionals will demonstrate how to assess local infrastructure at the state or city level. They will also share examples of sustainable solutions with renewable energy (e.g., solar-panel rooftop, wind, green energy, and electric vehicles) in cities, government policies on emissions reduction). For PM sessions, students will be provided with a guided site visit at one of the following: (1) an eco-industrial park, (2) green construction sites, (3) businesses using renewable energy and sustainable practices. For example, students will observe installations of an HVAC system which is built from recycled/upcycled/green technology. Students will learn more about how to re-calibrate barometric pressure, filter/clean air quality, reduce carbon footprint, and improve health. More PM sessions will engage students with hands-on activities (e.g., reforestation programs to plant trees in urban areas contributing to carbon sequestration and improve air quality). Students are also encouraged to interact with Generative AI (e.g., ChatGPT) with prompts to come up with more sustainable/renewal energy solutions (e.g., green building materials, eco-friendly construction, smart grids, AI-powered sensors, waste-to-energy systems).

e-Academy Day-5 (Innovation & Actionable Grassroot Initiatives). AM sessions focus on land pollution issues (e.g., deforestation, soil degradation, and landfill waste), with a special emphasis on innovative waste management solutions like recycling, upcycling, and composting. Students will visit a landfill, recycling center, or forest restoration project to understand the impact of land pollution and deforestation. PM sessions engage students to use digital tools (e.g., Google earth) to map deforestation in different regions and show the consequences of land misuse. Students will be challenged to propose sustainable solutions for reducing land pollution in their schools or neighborhoods. Students will practice writing effective prompts for ChatGPT or Copilot to generate an outline of innovative water-conservation campaigns to reduce water pollution (e.g., clean-ups, campaigns, plastic waste reduction, recycling programs, designing green spaces, microplastic filters, and bioremediation). Each group will present innovative ideas for tackling air, land, and water pollution, as well as promoting responsible food consumption.

Post-Academy Evaluation, Student Engagement & Leadership via a Student Ambassador Program

e-Academy student attendees are encouraged to take their projects back to school and act as ambassadors for the SDGs, creating clubs or organizing awareness campaigns. Teachers can serve as mentors to guide students how to implement their projects and set up an online platform where they can continue to collaborate and share progress. Student participants will be provided with resources and incentive (a stipend of $100) to become ambassadors of SDGs in their schools and communities to head up their proposed projects. Encourage students to take their projects back to school and act as ambassadors for the SDGs, creating clubs or organizing awareness campaigns. Examples of youth-led initiatives include school-wide food waste reduction programs, tree planting drives, or community clean-up days. Students are encouraged to present their projects at Science Fairs, local or regional events, conferences, or city council meetings to promote wider community involvement in SDG efforts. Student projects will be posted on the project website. Further, social media will be used to showcase students' projects and outcomes. By creating a digital portfolio of success stories can inspire others to act. By engaging students in hands-on, innovative learning experiences, this five-day summer program can foster a generation of environmentally conscious individuals who can pursue environmental careers to drive the UN 2030 SDG agenda.

Intervention # 4 AI-Powered Environmental e-Externship

The vision of e-Externship is to grow diverse talents in becoming future leaders who have the knowledge, skills, and technical abilities (KSA) to develop sustainable solutions through cross-industry collaboration, job shadowing, mentorship, interdisciplinary knowledge acquisition, transferable skill development, and real-world applications. The purpose of the e-Externship is to empower Gen-Z students, who are passionate about environmental sustainability, to co-implement AI-powered solutions with their mentors to solve societal and environmental complexities. Further, mentors will also train externs in how to conduct research with scientific methods or advocate grassroot initiatives by sharing institutional resources and professional expertise to cultivate and retain diverse talents. Moreover, mentors will help externs connect with what they learn in schools to real-world context and apply their knowledge to solve societal and environmental complexities with disruptive technologies in their schools, local communities, and global society.

Externs will have access to innovative tools, intelligent platforms, and virtual labs to conduct R&D and experiments. Externship projects are built upon five prior NSF and EPA grants (S3OK, EdPASS-H2O, Ayers Pantry & Consumption), EF4Girls, and Supercomputer Buddy) with linkage to the management of water, land, air, infrastructure, consumption, climate, and ecosystems. These grantees, who function as sponsors and mentors, will share their institutional resources, professional expertise, working knowledge, and technological infrastructure to support the proposed projects. The e-Externship aims to retain young talents via job shadowing, mentoring, knowledge acquisition, and skill development to support students, who wish to pursue environmental education-career pathways and become future data scientists, technologists, engineers, and mathematicians who can address the needs of tribal communities and complex environmental problems with sustainable and innovative solutions.

Pre-Externship Planning, Event Promotion, Eligibility, & Selection Criteria

Cross-industry professionals representing the GINOTU partnering institutions are engaged to co-design and sponsor e-Externship. These professionals also function as project supervisors and mentors. Social media campaigns will be used to promote e-Externship visibility. Former e-Academy attendees with academic excellence are eligible to apply. A computer algorithm will be used to randomly select five externs per year from subgroups of underrepresented students (e.g., women, minorities, the socio-emotional disadvantaged).

e-Externship Structure, Timeline, & Transferable Skills

Each extern will be paired with an Externship supervisor (an industry professional or academic mentor) who will help externs (1) identify real-world challenges, and (2) connect what they learned from the e-Academy and in schools implement solutions in industrial or community contexts. The externship will last

12 weeks during the summer months (June-August), allowing for collaboration with industry and community stakeholders, and implementation of solutions for any of the following environmental projects to address UN2030-SDG. Externs will work remotely via Zoom and mobile apps to stay in touch with their mentors when working on SDG-related projects. Externship activities are designed with interdisciplinary knowledge and practical applications of environmental sustainability via job-shadowing, knowledge-acquisition, and skill-development venues. These venues are designed to balance learning and hands-on activities to solve environmental problems innovatively. Hands-on experiences will be designed to foster soft skills, AI competency, and environmental literacy.

Week-1 Orientation & UN2030-SDG Overview. All externs are required to attend webinars/training sessions introducing the SDGs, specific challenges related to their chosen projects, and potential industry or community applications. Sponsors/mentors will guide externs to align with one or more SDGs and focus their global relevance and local applications. Professionals from cross-sectors and industries will discuss the context on current challenges and innovations. Externs will be encouraged to focus on a specific theme (e.g., clean water technology, environmental conservation, water conservation, sustainable infrastructure, or green technology) when working on challenges linked to each SDG.

Weeks 2 -11. The project team proposes the following externship projects (**Table 6, below**) which are designed for externs to gain real-world experience by working closely with cross-industry sponsors/mentors representing cross-sector GINOTU partnering institutions (e.g., governmental agencies, nonprofits, environmental engineering, sustainability consulting, and renewable energy). Externship activities will immerse externs to acquire, integrate, and connect inter-disciplinary knowledge to be derived from e-Academy. Externs will apply what they learned to co-design, co-implement, and co-test scalable solutions. Externs will also learn more about policy recommendations for improving the quality of water, air, land, and economic growth. These projects are designed for externs to work alongside mentors to learn more about sustainable product design, conduct waste audits/carbon footprint analysis, and biodiversity monitoring tools. Externs are expected to grow in their environmental literacy, soft skills, and AI proficiency which can be transferred into domains of emerging careers (e.g., Environmental Analytics, Environmental Forensics).

TABLE 6
AI-POWERED E-EXTERNSHIP TO SERVE THE INDEGINOUS COMMUNITY

e-Externship Project	SDG#	Sponsor	Technology	Skills
1. **Water Resource Management**	6, 9, 11, 17	EPA Grantee	AI, Machine Learning, Robotics, Blockchain, etc.	See Section # 2.4 (p. 6)
2. Life on Land	11, 15, 17	UCO		
3. Climate Change	1, 11, 13, 17	OKSC		
4. Responsible Food Production & Consumption	2, 10, 11, 12	DEQ		
5. **Earth Week: Recycling, Composing, etc.**	1, 2, 3, 11	UCO		

e-Externship Project #1 Water Resource Management to Promote Water-Industry Careers With Innovative Infrastructure. Sponsor and extern can choose one of the following proposed projects. These e-Externship projects are designed for the extern to explore innovative and sustainable solutions for enhancing water resources and water-related career pathways. The extern will learn to perform a waste audit at local businesses/schools to identify opportunities for reducing, reusing, and recycling materials.

- Water-efficient agriculture with or AI-smart irrigation systems via remote sensing to monitor water consumption in vulnerable regions urban wastewater treatment efficiency
- Deployable membrane distillation unit to test water quality & reusability for water sustainability

- Desalination to create innovative tools/affordable filtration technologies to produce/recycle water
- Declined Pollination (Recovery ratio of various feedwater-technology) to use solar-powered devices to turn seawater into drinking water

e-Externship Project #2 Life on Land to Reduce Pollution and Enhance Health. This project builds onto *NSF-S3OK* and *NSF-EF4Girls* grants to continue exploring sustainable infrastructure and industrial innovations to enhance the quality of life on earth. Prospective projects to deepen understanding of land biodiversity, deforestation, ecosystems, and sustainable farms are as follows:

- *Sustainable Agriculture Initiative* to collaborate with local farmers and explore sustainable farming techniques (e.g., agroforestry, organic farming)
- *Bioinformatics* to study wildlife and endangered species
- *Plant Biodiversity Monitoring Program* to study local ecosystems
- *Reforestation and Habitat Restoration* to plan for restoring degraded land
- *Bioinformatics* project to study wildlife or endangered species the extern will also be exposed to Data Science, scientific methods, and computer languages (e.g., R programming) that are used to gain better understanding of the biological data (DNA, RNA) of endangered species relating to environmental factors.

e-Externship Project #3 Climate Change to Improve the Quality of Air via Renewable Technology & Sustainable Solution. This project focuses on Data Science and Environmental Analytics by building onto the *NSF-S3OK* grant to explore sustainable solutions, mitigation, and adaptation strategies. The extern can choose one of the following climate-related projects: The project sponsor will job shadow how to integrate any of these projects into local schools or community centers. The extern will design a social media campaign to promote environmental literacy and advocate sustainable solutions for climate change.

- Accessibility to advanced green technologies (e.g., GIS, 3D printing for prototyping, NASA's *Climate Change Simulation)*
- Renewable energy testbeds such as solar, wind, and bioenergy for low-income community/areas
- CSR, ESG, & carbon offset programs to reduce carbon footprints of businesses, schools, or homes
- Guidance for conducting sustainability research with scientific rigor for data collection, analytical methods, lab work, field studies, and prototype development for scaling solutions.
- Strategies for climate adaptation and resilience in vulnerable communities to create urban green spaces or solutions for coastal regions which are prone to rising sea levels.

e-Externship Project #4 to Promote Responsible Production & Consumption. This project, which is built upon prior *NSF-S3OK and DEQ-Ayer Food Pantry*, will engage an extern in one of the following projects. Externs will gain better understanding about the importance of responsible food production, consumption, and sustainable lifestyles with food choices to sustain the ecosystems via efficient use of resources.

- Develop a circular economy campaign to drive innovation via sustainable production & consumption (e.g., Design products and packaging using eco-friendly/ biodegradable/ recyclable materials materials)
- Use software to track a product's life to reduce environmental waste & improve sustainable practices
- Research into sustainable supply chains & ethical production in urban communities
- Develop a certification program for sustainable product life cycles
- Design a mobile app to track the food surplus of nearby restaurants or schools & redistribute to the nearby food pantry to feed the hunger in the local community

e-Externship Project #5 Earth Week to Promote Environmental Sustainability & Public Literacy. The mentor will guide the extern to design and implement an *Earth Week* to educate the public about

grassroot efforts by volunteers to sustain the ecosystems and our environment. Examples of student-led initiates include composting, recycling, organic farming, and food choices) to promote sustainable community of practices. Students will also promote healthier choices that are better for health and the environment. For instance, eating less meat as nutritionists' recommendation since manufactures use more water to process meat. Another practical practice is to carry a reusable water jog to reduce plastic bottles (environmental hazard for land and ocean as they contain plasticity that is harmful for humans and fish to ingest. Another actionable practice is to share car rides, bike, or walk to reduce carbon emission.

Week 8: e-Externship Presentations. Each extern will present his/her summer project to a panel of experts who are professionals and community leaders. Externs will receive feedback to continue SDG projects in their local communities. Externs are also required to submit a report (a project artifact) to highlight how their Externship projects address critical challenges in one or more SDG areas, with a clear plan for real-world application. Further, externs who show ow a capacity for collaboration with their communities to address their local needs and innovative solutions will receive a stipend and a digital badge.

Status & Deliverable. Externs must submit weekly progress reports on research progress, challenges, and milestones. Mentors will provide feedback on research quality and practical application. At the end of the Externship, students work in teams to propose an innovative solution that addresses one or more SDGs they focus on during the Externship. Example projects: Propose a school-wide water conservation program, design a small-scale renewable energy system for a community center, create a plan to reduce waste and increase recycling at a local business, or propose reforestation projects in local parks. *Extern Recognition*: Recognize outstanding projects with awards or scholarships and offer opportunities for students to present their solutions at conferences. By focusing on real-world applications, hands-on learning, and mentorship, this high school Externship provides students with venues for their contribution towards SDG goals.

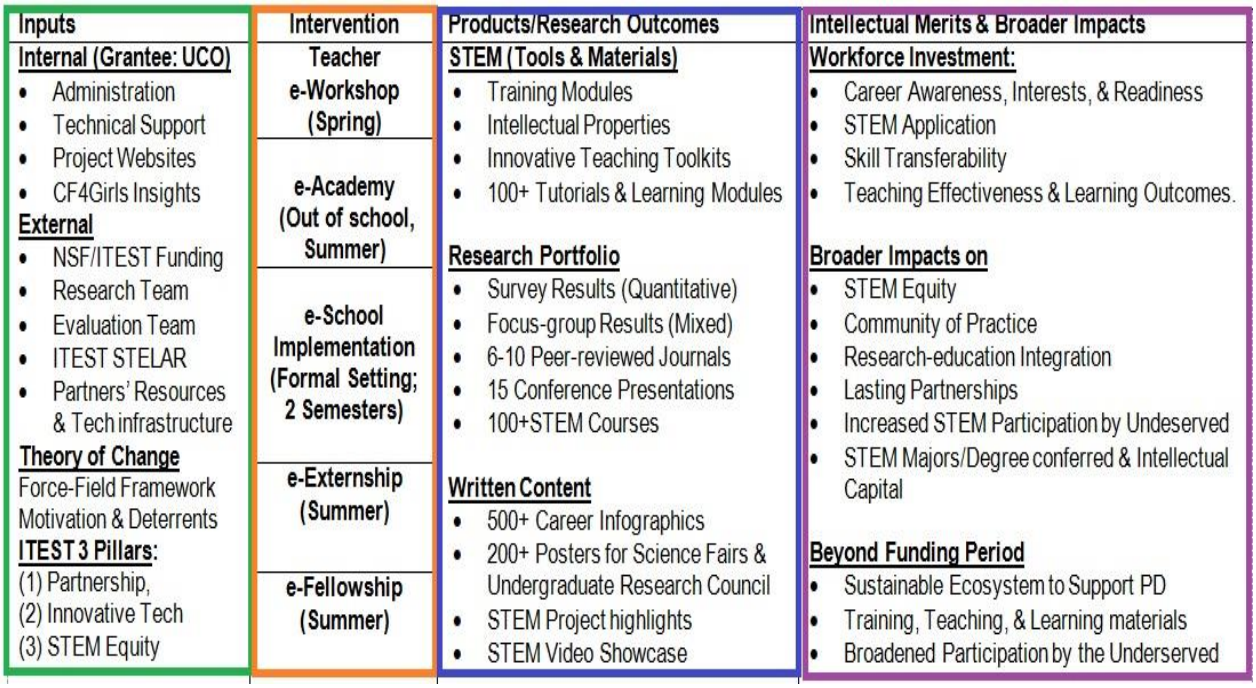
Post-Externship & Callable Actions for Public Engagement & Community Services

To promote leadership, former externs will be championed to lead grass-root initiatives in their schools and community services. They will also continue to promote environmental initiative visibility with poster presentations at the Science Fair, the annual Oklahoma Research Day, and the EPSCoR's STEM Conference. To promote knowledge management, transfer, and sharing, former externs are also encouraged to co-present with their mentors or teachers at the AI-powered e-Conference which functions as an annual symposium for researchers, practitioners, and educators to engage with policymakers, industry leaders, and the public. Other media engagement includes sharing program outcomes through social media, environmental blogs, and SDG-related platforms. LinkedIn with QR codes will also be adopted to promote e-Externship Network that supports externs after the program ends, helping them continue their work, pursue environment-related education-career pathways. These post-externship activities are designed as continuous support for the diverse talents to pursue college degrees and join the future STEM workforce.

METHODOLOGY FOR PHASE-II RESEARCH STUDY

This Phase-II Research component of the UN2030-SDG project will be guided by a logic model (**Figure 6**) in how the proposed programs affect participants and impact global society. An internal board review (IRB) will also be obtained prior to any of the following research activities to expand the research capacity and catalyze environmental solutions by leveraging GINOTU's institutional resources, existing technological infrastructure, and professional expertise.

FIGURE 6
A LOGIC MODEL TO EXPAND ENVIORNMNENTAL EDUCATION-RESEARCH CAPACITY



Research Questions (RQs)

The project team seeks to deepen understanding of whether existing science-based research is a sustainable solution for combating educational, professional, economic, and environmental challenges by enhancing terrestrial resource management to sustain ecosystems. The project team asks the following RQs:

1) *To what extent does AI-powered e-Conference affect participants' outcomes?*

2) *To what extent does AI-powered e-Workshop affect teacher participants' outcomes?*

3) *To what extent does AI-powered e-Academy affect student participants' outcomes?*

4) *To what extent does AI-powered e-Externship affect student participants' outcomes?*

Data-Collection Protocols

Research instruments will be pilot tested to ensure reliability and validity. Surveys will reside on UCO's Qualtrics server. Quantitative and qualitative (mixed) data will be derived from the pre/post surveys by teacher and student participants. Qualitative data will be derived from the focus group (FG) of participants.

Research Metrics & Analytical Method

Research instruments and metrics (**Table 7)** to track the progress of each proposed intervention will be piloted to ensure program efficacy, validity, and reliability. The proposed activities and environmental data are semantically linked to the research objectives and research questions (RQs) are formulated to gain insights on how to solve complex environmental complexities by expanding research capacity, sustaining ecosystems, and replicating AI-powered models. Findings will be triangulated to form the basis for answering RQs: Program calibration will be made to better serve project stakeholders and communities.

TABLE 7
RESEARCH METHOD IN RELATION TO RQS AND PROGRAM OBJECTIVES

Obj	RQ	Environmental Instrument	Analytical Method	Program Outcomes
1	1	e-Conference Survey	Factor Analysis, t-test, & Thematic Coding	Multi-metrics will be used to assess the socio-emotional & cognitive outcomes, as outlined in Logic Model (**Figure 7,** above).
2	2	e-Workshop Pre/Post Survey & FG		
3	3	e-Academy S Pre/Post Survey		
4	4	e-Externship Pre/Post Survey & FG		

Data Collection & Analysis for Answering RQ#1 (Effects of e-Conference on Diverse Participants)

The pre/post e-Conference surveys will be administered to attendees to collect mixed data. The pre-test is to establish the baseline of any prior environmental literacy. A statistical procedure (e.g., t-test) will be performed to compare any differences (e.g., percentage of increases) in attendees' environmental literacy (e.g., awareness of technological advancement and emerging environment-related careers) after their e-Conference attendance. The post-survey will also prompt teacher attendees to self-report deterrents and needs for them to adopt, adapt, and teach courses with environmental content. Factor analysis will be performed to rank the top five factors. These factors will guide the e-Workshop design to overcome challenges. Findings to be derived from the data analysis will form the basis for answering RQ#1 about how the proposed AI-powered e-Conference affect attendees' environmental literacy. Evaluation will also be performed to determine if the program objective has been achieved by using metrics (e.g., attendee engagement, social media reach) to measure the success of the e-Conference.

For the focus group, teacher attendees will also self-report on what deterrents and needs for them to adopt, adapt, and teach courses with environmental content. Factor analysis will be performed to rank the top 10 factors. These factors will be carefully considered when designing the e-Workshop to train teachers. e-Conference outcomes will be shared with project stakeholders through a post-conference evaluation report which includes actionable insights, next steps, and commitments made during the event. By utilizing an inclusive, collaborative, and engaging approach, e-Conference can be a powerful precursor to guide the e-Workshop design for promoting and driving progress on the UN 2030 SDGs.

Data Analysis for Answering RQ #2 (Effects of e-Workshop on Educators)

The proposed e-Workshop is designed to enhance professional proficiency of tribal teachers and homeschool parents (collectively as "educators" hereafter) so that they can incorporate UN2030 SDG topics in their STEM curricula, teach with innovative technologies in their own classrooms, and promote environmental education in their schools. The research team will administer pre/post e-Workshop survey to participants. The pre-test is to establish the baseline of any knowledge and competencies. UCO will analyze quantitative data derived from the surveys via a statistical procedure to compare differences/increases in attendees' environmental knowledge and technical competencies before and after the e-Workshop attendance. Collected data will be analyzed to assess the program efficacy and effects on participants. Findings will form the basis for answering RQ #2, How *does AI-powered Environmental e-Workshop affect teacher participants' outcomes? to show any pre-post increases in teachers' knowledge, skill, and technical abilities (KSA).* Evaluation will also be performed to determine if the program objective has been achieved. Teacher participants are encouraged to join the teacher focus group (FG) voluntarily. Thematic coding will be performed to analyze the qualitative data derived from the FG.

Data Analysis for Answering RQ #3 e-Academy Effects & Impacts

To achieve program objective #3 to promote environmental career awareness and interests, the proposed s with the proposed AI-powered e-Academy, the project team will administer pre/post survey to student participants. The pre-test is to establish the baseline of any knowledge before attending the e-Academy. and competencies. UCO will analyze quantitative data derived from the surveys via a statistical procedure to compare differences/increases (e.g., percentage of increases) in attendees' environmental

knowledge and technical competencies before and after the e-Academy attendance. Teacher participants are encouraged to join the student FG voluntarily. Thematic coding will be performed to analyze the qualitative data derived from the FG. Findings will form the basis for answering RQ #3, *To what extent does AI-powered Environmental E-Academy affect student participants' outcomes? to show any pre-post increases in teachers' KSA*. Evaluation will also be performed to determine if the program objective has been achieved.

Data Analysis for Answering RQ #4 & e-Externship Effects & Impacts

To achieve program objective #4 to promote environmental innovation and economy via the proposed AI-powered e-Externship, the project team will administer pre/post survey to participants. Collected data will be analyzed to assess the program efficacy and effects on participants. The pre-test is to establish the baseline of any knowledge and competencies. UCO will analyze quantitative data to be derived from the surveys via a statistical procedure to compare differences/increases in attendees' environmental knowledge and technical competencies before and after the e-Externship participation. Findings will form the basis for answering RQ #4, *How does AI-powered Environmental e-Externship affect participants' outcomes?* Evaluation will also be performed to determine if the program objective has been achieved by tracking the effects of proposed on project stakeholders. A scripted interview (instead of survey to collect quantitative data due to the small sample size) will be adopted to assess the effects of intervention/program on externs. Thematic coding will be performed to analyze the qualitative data to assess how these interventions/program impacted interns and fellows to pursue their education-career pathways. Other outputs/products/Artifacts include posters of sustainable solutions for venues such as Science Fairs, Oklahoma Research Day, symposium, or conference.

PROJECT EVALUATION & IMPACTS ON GLOBAL SOCIETAL

This UN2030-SDG project with proposed interventions and supporting activities aims to expand education-research capacity are potentially transformative for educators, students, researchers, practitioners, and institutions. The UN2030-SDG model features equity, diversity, and inclusion (DEI) as well as scalability, replicability, sustainability, proficiency, and engagement that enhance both the present and future generations. The project team targets diverse participants, who are underrepresented (e.g., women, minorities, native Americans, disabilities) to broaden versatility for higher proficiency in STEM.

The project team also adopts an innovative management process to leverage existing technological infrastructure, institutional resources, and professional expertise. By transferring technology and sharing collective knowledge from prior work, the proposed interventions have the potential to broaden and deepen societal impacts by addressing the following UN's sustainable development goals (**Table 8, below)**. Foundational knowledge and technology transfers, which aim to support the proposed AI-powered programs, are designed to function as an environmental bridgeways to engage teachers and students in grass-root initiatives. The proposed AI-powered interventions can foster impactful solutions across SDG sectors, developing innovations that contribute directly to clean water, sustainable infrastructure, responsible consumption, climate action, and land conservation. By combining mentorship, interdisciplinary collaboration, and community engagement, these innovative programs can accelerate progress toward the UN 2030 agenda.

TABLE 8
BROADER IMPACTS OF THE PROPOSED UN2030-SDG INTERVENTION INNOVATIONS

UN2030-SDG & Description	e-Conference	e-Workshop	e-Academy	e-Externship
1. No Poverty	**X**	**X**		
2. Zero Hunger	**X**		**X**	**X**
3. Good Health & Well Being		**X**		**X**
4. Quality Education	**X**	**X**	**X**	X
5. Gender Equality		**X**	**X**	**X**
6. Clean Water	X	X	X	X
7. Affordable & Clean Energy	**X**		**X**	X
8. Economic Growth & Jobs	**X**	**X**		**X**
9. Industry, Innovation, & Infrastructure	X	X	X	X
10. Reduced Inequity		X	X	X
11. Sustainable Cities & Communities	X	X	X	X
12. Responsible Consumption/Production	X	X	X	X
13. Climate Action	X	X	X	X
14. Life below Water	X	X	X	X
15. Life on Land	X	X	X	X
16. Peace, Justice, & Strong Institution	X	X		
17. Partnerships for the Goals	X	X	X	X

Further, these interventions also encourage the younger generation by fostering leadership to amplify their voices of those directly impacted. Moreover, this UN2030-SDG project also benefit project stakeholders to (1) maximize the federal-state investment by improving the research infrastructure, workshops and outreach, data collection, and stakeholder engagement; (2) generate jurisdictional outcomes (e.g., increased awareness of environmental issues, interests in emerging careers, and degrees conferred) and research products (e.g., publications, patents, grant proposals, and funding awards); and (3) enhance EPSCoR impacts to catalyze environmental research capability across and among jurisdictions by diverse groups and institutions. Innovation management via technology and knowledge transfers can afford the project team to promote innovative and sustainable solutions for addressing workforce and environmental challenges by converting innovations into economic opportunities in our state and nation.

To sum up, the proposed intervention innovations have the potential to transform education and bolster the environmental research capacity to benefit project stakeholders. The project team adopts an innovation-management process to transfer technology and knowledge. Findings gained from Phase-I and Phase-II provide the project team with insights on how to advance environmental research on broadening impacts across quality education, water resources, infrastructure, land management, food insecurity, and poverty. Working knowledge also forms the foundation for developing a competitive grant to secure federal funding and corporate investment to build upon the tested conceptual, theoretical, and technological frameworks. Additional funding and resources enable the project team to continue engage project stakeholders in open dialogs to address environmental equity since addressing global society complexities requires synergized collaborations in the research community to benefit all stakeholders in other EPSCoR states in the regions and across U.S. Building an equitable, diverse, and innovative workforce of data scientists, technologists, robotic engineers, and computing mathematicians who can solve complex environmental problems with innovations and sustaining the ecosystems on the human-computer frontier is critical for the quality of lives on this planet.

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