PROJECT SUMMARY

Overview:

This pathways project will result in an interactive, online platform that will educate and engage users through interactive discussions and contributions to STEM research. Online information about current STEM research topics is usually passive in nature (read or view), of varied or difficult-to-determine trustworthiness, and when legitimate is often written at a level only accessible to experts in the discipline. Informal learning experiences such as those offered by museums, zoos, and science centers have the benefit of being interactive and well vetted, but are not accessible on an anywhere/anytime basis. The online companions to these in-place experiences may include rich interactivity, but the subjects are more likely to be about basic principles or fundamental concepts rather than about current research projects. Ripple builds on existing technologies that support sharing of user-contributed information and will be structured around topic areas with scientifically trustworthy material that will serve as the seeds for discussion, discovery and engagement. The Ripple platform will be built on the cyberinfrastructure of HUBzero, which combines unique middleware with Web 2.0 functionality to facilitate user participation in a self-sustaining community of users and contributors. The target user population for Ripple is students in late-high school or early-undergraduate. Ripple's interactivity will include scientific simulation tools that invite the user to explore the effects of different parameters on the outcome of an experiment, data input areas for users to contribute to ongoing research and questions and discussions with badge-earning algorithms for rewarding and tracking user participation. These features are intended to foster a truly social approach to STEM learning.

Intellectual Merit :

Social networking is a way of life among the student-aged population, with every indication that this means of interacting with other people will only continue to proliferate. Informal STEM learning permits learners to independently construct experiences that allow them to engage with and explore content outside of a classroom setting. The Ripple pathways project will begin to explore the means by which the social media dynamic can map onto the informal learning experience. The design of the Ripple platform will take into account research on the emergence and supports for community in online environments as well as the motivators of involvement as laid out by stakeholder theory. The goal will be for the platform to foster a high level of interaction among users in a multi-directional way, including researchers whose content is featured and students who seek to learn about that content. The design of the platform will also be structured to support the six strands of informal science learning. Because the users can engage in exploration of the behavior of data, contribute to data gathering, and participate in discussions, we anticipate that the site will particularly support scientific reasoning and the use of the language of science.

Broader Impacts :

Ripple will provide researchers in science and engineering the opportunity to share their work directly with a non-expert audience. They will be able to use the platform to disseminate their work and have that contribution archived and referenced as scholarly work. Having Ripple users contribute data, ideas, and questions may help to drive the research work forward. Ripple will provide students with a source of scientifically trustworthy and vetted information that is targeted to their level of interest and understanding. As such, we hope that it will increase user understanding of and interest in specific science content as well as enhance general, science process knowledge.

In its fully developed state, we envision that Ripple will assist in the development of strategic insight for the growing phenomenon of digital engagement, allowing us to gather information about online participation drivers and develop best practices for digital engagement and participation. This will benefit all online informal science learning efforts, even those associated with museum exhibits, since the social learning dimension could be extended to improve those experiences.

Ripple – A Social Interactive Platform for STEM Discovery

A. Project Rationale

Alicia, a high school senior, became interested in the idea that liquid transportation fuels can be made from plant material after learning briefly about biofuel conversion in her chemistry class. She wants to know more about it. What kind of plants can be used? What is the process? How much does it really cost compared to fossil fuels? If Alicia searches online for information on the subject, she will find a plethora of sites, books and articles – many from reputable sources, but some not. Most of those that are from scientifically trustworthy sources are written at a level that is rather intimidating to her. All of them are passive sources of information, offering her an opportunity to read text or to view videos. The interactivity that she enjoys in other informal learning environments, such as science museums, is largely missing from the material that Alicia will find in her online or library searches about transportation fuels from plants. However, she can do those searches anytime and from anywhere that she can connect to the internet.

At the same time, Alicia lives in a social environment that includes conversations with a multitude of people from every corner of the world. She shares information with them and, in turn, gains access to links, photos, videos and comments shared by her circles of friends or followed contributors. This social environment is also at her fingertips in an anytime, anywhere manner, and is part of her everyday life.

This AISL pathways proposal will be a first step toward the exploration and development of an interactive, online platform that can provide students like Alicia with vetted information within a *social learning* setting about scientific, technological and engineering topics that are at the forefront of research. The proposed **Ripple** platform will build on the powerful architecture for scientific collaboration provided by HUBzero (HUBzero) and will be designed to encourage media-facilitated, self-guided exploration of content, interaction between novices and experts, and scientific discourse among a diverse user group. The plan for the fully-developed Ripple site is that it will include a topic- and discipline-searchable collection of "pebbles," which are discussion and engagement areas each devoted to a particular STEM topic currently being researched. They will include content (text, graphics, videos), but will also feature interactive tools for users to explore and contribute to data as well as participatory components for community discussion and questions. For this pathways project, the goals are:

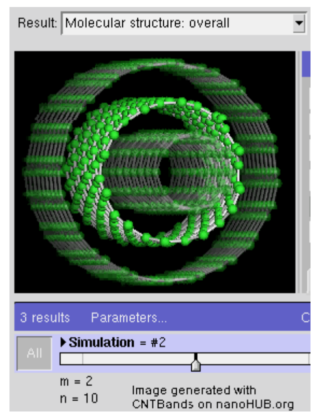
- Develop a beta version of the environment that includes two pebbles and user interaction tools.
- Establish the framework for a "mutual benefit" model for contributions by scientists that will enhance their research while also informing the user base.
- Generate a user participation model that will be self-propagating.
- Assess the usability of the beta environment and utilize those results for a revision plan.
- Examine the user engagement experience with respect to the strands of informal science learning (National Research Council, 2009) and with respect to digital communities of practice (Wenger, White, & Smith, J. D., 2009; Hur & Brush, 2009) and social networks (Britt & Matei, 2011).

This proposal emerges from a vision of Ripple as a vibrant, interactive, virtual community that facilitates multi-directional flow of information, resources, connections and support for discovery. The target user audience is students in the late-high school to early-undergraduate years; the target pebble contributor base is researchers involved in STEM (science, technology, engineering and mathematics) or STEM-related (such as medicine and agriculture) projects, and will begin with researchers specifically at Purdue who will work closely with the Ripple development and research team.

Informal Science Learning through Ripple

A framework for learning in informal environments was laid out in the NRC book *Learning Science in Informal Environments* (National Research Council, 2009) comprising six strands. Ripple holds promise to be able to address informal learning along all six of these strands to varying degrees.

1. Sparking interest and excitement. The *pebbles* in Ripple will include video and graphics that will describe a current research topic and will, in particular, focus on its connections to the everyday world. The design and specific components of each pebble are intended to generate interest.
2. Understanding scientific content and knowledge. Because the pebbles will be about research topics, rather than isolated principles or phenomena, the content will provide a view of how concepts from different disciplines are linked. For example, the researchers studying the conversion of biomass to liquid transportation fuels are using chemistry techniques, biological principles and an agricultural context. While the fundamental ideas relate directly to introductory courses in these disciplines, students may not have other opportunities to see how these can be linked to address complex questions.
3. Engaging in scientific reasoning. Each pebble will include at least one interactive simulation of data in which students can manipulate variables and see the effect on the system. The nanoHub (NCN), which launched the HUBzero (HUBzero) architecture, was built around the sharing of these simulation tools, which have become both drivers for new research questions and powerful educational resources. The simulations will support exploring, questioning and predicting by student users. In addition, users will have the opportunity to contribute their own data and to visualize the collection of data from the user base in appropriate ways (maps, charts, etc.), which will support students in developing explanations based on evidence.



4. Reflecting on Science. As described in *Learning Science in Informal Environments*, (National Research Council, 2009) "When people are provided with opportunities to learn about the problematic nature of scientific knowledge construction, to understand the process of modeling and testing…their understanding of the nature of scientific practice, process and knowledge improves." The projects comprising each pebble will be ongoing research projects in which researchers will describe not only the subject matter but also their process. Users will have an opportunity to see how researchers from different disciplines collaborate on and contribute to finding answers to many-dimensional questions. By being contributors of data themselves, the student users will become part of the process of that scientific investigation. This is a direct way of experiencing the nature of science, which is often only revealed to students through historical accounts or by an algorithmic list of steps.
5. Using the Tools and Language of Science. The Ripple platform holds particular promise to be able to support student learning along this strand. In the book *Surrounded by Science: Learning Science in Informal Environments* (Fenichel & Schweingruber, 2010), the authors state that "science is a

social process, in which people with knowledge of the language, tools, and core values of the community come together to achieve a greater understanding of the world." By bringing together the strengths of social media with STEM content for students, Ripple will be a *social learning* environment based on interaction and discussion. Students will use and be exposed to the language of science. Through the visualizing of data they will have the opportunity to use the computer-based tools of science.

6. Identifying with the Scientific Enterprise. The ability to contribute to ongoing research efforts and to investigate the behavior of user-contributed data within visualization tools on Ripple places the student user in the role of scientific investigator. This is a necessary, though not sufficient, step in helping them to develop identity as part of a scientific community. Additionally, the discussion elements of each pebble can further help users to identify as part of a scientific community.

In this pathways project, we will be focusing on the design of the platform and the ways in which different tools and elements of the pebbles function. These design considerations will be particularly focused on achieving or maximizing the impact on the six strands described. Assessment efforts at the pathways level will be mostly formative in nature, helping us not only to revise the site but also to plan more extensive, longitudinal assessments for assessing strand outcomes.

Social Networking and Communities

Ripple is significant in that it brings together social networking elements of interaction with informal science learning online. It is of particular interest to our team to support and understand the formation of scientific communities using Ripple and the nature of the interactions within those communities.

The framework for developing the Ripple community of practice is informed by Wenger's Digital Habitats (Wenger, White, & Smith, 2009). The elements of Wenger's definition of communities of practice (CoP) are: a domain of knowledge, a shared practice and a community of people passionate about this domain (Wenger, E., 2002). Online communities of practice are well-suited to fostering a collaborative environment that promotes idea sharing and peer support (Park, 1998; Heider, 2005). Within the community of users, the opportunity to learn from more expert others may facilitate the learning process. In this project, we will follow the Preece and Schneiderrman framework (Preece & Schneiderman, 2009) for fostering participation, which promotes a "ladder" of participation and involvement, advancing from "reader to leader." Our project will draw on the sociability and usability principles recommended by Preece and Schneiderman by including features in the platform that foster in-the-right-amount and at-the-right-time transitions from reader to contributor, collaborator, and ultimately community leader roles. Creating role-related features and sociability affordances in Ripple will be important for motivating the sharing of information among users (Huffaker & Lai, 2007; Hummel, Burgos, Tattersall, Brouns, Kurvers, & Koper, 2005). Roles and a ladder of activities require the existence of an undergirding community to support them. The existence of "community" is particularly important as a support for the exchange of information and expertise because expert-novice relationships can change and shift dynamically during the course of an interaction. (Jacoby & Gonzalez, 1991) Students' participation in scientific discourse about the Ripple topics can be expected to promote learning as well as provide the project team with insights about the users and the community as a whole (Fenichel & Schweingruber, 2010; Brown, Reveles, & Kelly, 2005).

While supporting individual user engagement and learning is a primary goal for Ripple, the social learning aspect of the project dictates that the community as a whole is one that must become self-sustaining. In self-sustaining online communities, there are patterns of interaction that can be modeled to shed light on the processes of contribution and collaboration, as well as the emergence of leadership when a critical mass is attained (Britt & Matei, 2011). These social dynamics can be influenced by the design of the platform (Matei, 2010). Furthermore, stakeholder theory (Roelofsen, Boon, Kloet, & Broerse, 2011) and the reader-to-leader framework illustrate the ways in which levels of involvement (i.e. each individual's stake in the process) can influence the types of interactions a stakeholder has with the community. We aim to create an environment for scientific discovery that holds mutual benefit for researchers contributing content and users who search for and ultimately engage in that content. We will work with the fundamental ideas about online community emergence and user/stakeholder engagement to inform, study and revise the Ripple platform design so that it will be self-sustaining and self-propagating.

Who wins?

There will be two primary groups of stakeholders in the Ripple environment, and two additional groups of contributors. In order to succeed as a social learning environment, Ripple must provide each of these groups with a motivation to be part of it and some gain as a result of participating.

STEM Researchers

The structural units of Ripple will be the "pebbles," each of which will be a self-contained discussion and engagement area based on a topic of current research. A pebble must be initiated by the publication in Ripple of content and tools based on the work of a researcher or research team. There are several benefits to the research team in doing so. First, the HUBzero platform is inherently built for the professional publication of research work. Content published within the HUB has the ability to generate a DOI (Digital Object Identifier), providing the work with a persistent identification to be cited, located and archived. For example, nanoHub.org has 960 citations in nanotechnology research with over 1,660 authors, 77% of whom are from outside the Purdue nanoHub community.

A second benefit to STEM researchers is in the area of broader impacts. Many researchers seek high-impact, meaningful ways to communicate their work beyond the expert audience of their immediate domain. The educational mission of Ripple and its potentially global reach would enable scientists and engineers to communicate to an eager audience about the value and excitement of the work they are engaged in. In addition, they can have this reach within an enterprise that will be stable and supported by other individuals, thus freeing them to focus on the STEM content and process.

A third benefit to the STEM researchers is in the direct contribution to their ongoing work. Ripple will utilize a "crowd sourcing" (Brabham, 2008) or "citizen science" (Hand, 2010; Bonney, et al., 2009) model of soliciting input from the user base. This approach has been used successfully by a wide variety of types of projects to generate new data or examine large datasets using a volunteer, participatory model and has led to publications with these data (Brabham, 2008; Bonney, et al., 2009; Hand, 2010), even though there are admittedly limitations to be taken into account with respect to data generated this way. Each research topic in Ripple will include at least one user-contributed research activity that will legitimately provide substantive, scholarly benefit to the ongoing research project. By having a suite of flexible examples and adaptable tools to this purpose, researchers using Ripple will be able to quickly plug into the citizen science phenomenon and increase their data analysis or generation capacity.

Student Users
The partner group to the STEM researchers to benefit from Ripple is the target audience: the student user. Alicia and her peers will be able to find information on current research in a social, participatory environment with content that has specifically been targeted to their level.

While there are numerous citizen science sites available on the internet, most are about a single, specific project or task (examples include Galaxy Zoo or Bat Detectives). Some sites maintain catalogs of citizen science projects in which people can participate, such as the Scientific American Citizen Science site (Scientific American, 2012), Citizen Science Central (Citizen Science Central, 2012), Zooniverse or the Citizen Science Alliance (CSA). Many of these simply consist of links to project websites with no underlying uniformity in the presentation of the material. The type of citizen science involvement will vary widely among these projects, ranging from field volunteer opportunities to at-home analysis of researcher-generated data based on a "microwork" paradigm. Most of these sites do not provide ways for the user community to engage with one another. Ripple will provide students with a standardized format that is intended, first and foremost, *to inform* the students so that they can learn and become interested in the topics at hand. They will be able to search categories of topics by discipline or keyword, (using the built-in Web 2.0 tagging system on the HUB), or jump to a featured project for that week in order to learn about something that may be completely new to them. The pebbles will include links to other pebbles in cases where one type of research has overlap with the activities or methods of another. In this way, students can begin to see the inter-related nature of the scientific enterprise, and the ways in which disciplinary boundaries become truly blurred at the research level.

Student Authors
Purdue University has a very active and extensive STEM undergraduate research enterprise with approximately 3000 students participating in faculty-mentored research every year and 30% of undergraduates engaging in research at some point during their studies at Purdue. A recent addition into this already successful engagement of undergraduates in research is the Journal of Purdue Undergraduate Research (Purdue University Libraries, 2012) which was launched in 2010 and has now published two volumes, with volume 3 in preparation. The most recent issue was published in July 2012 with 11 full-length articles and 38 "research snapshots" written by undergraduate students (as sole or lead author) who engaged in faculty-mentored undergraduate research on a broad range of STEM topics (e.g. aerospace, bioterrorism, protein science, geology, mechanics, and chemistry). Proposals for articles and the final articles themselves go through a rigorous review process by faculty members of the editorial advisory board, with an acceptance rate for full articles of approximately 40%. Student authors are supported by a student editorial board through the writing and submission process. Both student authors and student editorial board members had self-reported learning gains (Weiner, 2012) about the publishing process, writing for publication, distilling concepts, using evidence to draw conclusions and support claims, synthesizing information from multiple sources and evaluating the credibility of sources, among others.

The student authorship and editorial board model has been extremely successful as reported by students involved as well as faculty mentors and university administrators, but also from the perspective of meeting the goals of engaging undergraduate students directly in the processes of authoring and publishing scholarly work. The Ripple project team includes members of the Purdue University Libraries and Purdue University Press as co-PI's and senior personnel. We plan to develop a student editorial and authorship model for the development of the pebble content. This approach serves two purposes: to assist researchers in producing the content and to provide content that is at an appropriate level for the interests and skills of late-high school and early-undergraduate students interested in STEM topics. The student author teams will be coordinated by co-PI Watkinson, who has experience with and interest in the promotion of writing and publishing by students, and will be drawn from students involved in the pebble research projects themselves as well as students outside of those projects who are interested in STEM communication.

Other Users

While Ripple and its content will be targeted to student users in approximately the 16-20 age range, the platform will be open to anyone who chooses to use it. From this perspective, it is possible that other segments of the population may benefit. For example, while we do not propose to specifically provide materials for teachers as part of this pathways project, teachers of the target audience may find the site useful as a resource. Younger students or adults in the general population with an interest in STEM may also benefit.

Results of Prior NSF Support

The proposed project builds on and is informed by prior NSF supported projects, as follows:

Science Learning through Engineering Design (SLED) Targeted Partnership (0962840, $6,793,800, 2010 – 2017). Co-PI: Gabriela C. Weaver. To increase grade 3-6 student learning of science by developing Indiana's first integrated, engineering design-based approach to elementary/intermediate school science education. This project is building a teacher/researcher community of practice using HUBzero technology that will inform infrastructure development for Ripple. Further, teachers and researchers involved in SLED will help populate the Ripple community.

Intellectual Merit – SLED is developing a model for collaboration between STEM disciplinary faculty and 3-6th grade teachers to adapt and develop engineering design-based tasks that enhance student learning and understand of science concepts. Research will investigate both how 3-6th grade teachers teach science through the engineering design process and how students learn through design-based activities.

Broader Impacts – This project will directly impact over 200 elementary and intermediate school teachers and 100 pre-service teachers in the use of engineering design to teach science through authentic, inquiry-based multidisciplinary design projects. Moreover, it will develop a library of tested, design-based curricular materials to support 3-6th grade science teaching and create a cyber-infrastructure-enabled community of practice related to science education through engineering design that can disseminate both the model and the materials nationally and internationally.

A Sustainable Energy Concepts Professional Development Model for Rural Schools and Its Extension to a Systematic Approach for Integrating STEM Research and Education (0963621, $1,250,000, 2010-2015). Co-PI: Gabriela C. Weaver. To establish a systemic approach which connects interdisciplinary STEM research activities with educational pursuits and has a deliberate focus on broadening participation in STEM disciplines in rural communities. The project model is designed to engage teachers in rural high schools with researchers and their research activities. Rural teachers and their students will be involved in global "grand challenge" research endeavors, initially associated with biofuels and sustainable energies, in order to spark interest in STEM disciplines. Lessons learned from this project, which uses a HUBzero powered community of practice to link researchers and teachers, will inform Ripple development.

Intellectual Merit - The intellectual merit of this project lies in two areas. First, we will contribute to the research base on rural STEM education. Our assessment activities will allow us to develop an understanding of the factors that can have an impact on improving preparation and retention of

teachers in rural schools, and on preparation and recruitment of rural students to STEM disciplines. Second, we will be *developing* curricular materials for integrating sustainable energy concepts with state science standards.
Broader Impacts - The model development component of this project will directly impact approximately 40 rural in-service teachers, 80 pre-service rural teachers and all of their students. It will indirectly impact an additional approximately 400 rural in-service teachers and their students through academic year outreach activities. Furthermore, an outcome of this project will be to develop a systemic approach to integrating research with education, allowing us to continue to transform STEM education with this model into the future.

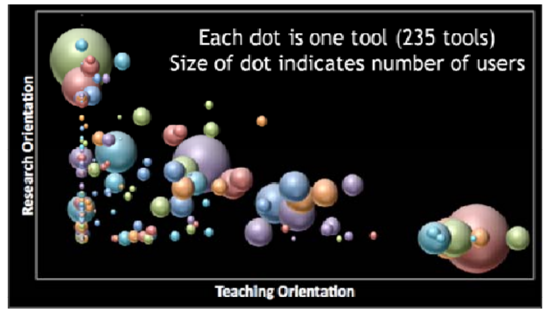
DRL: KredibleNet - Building a research community and proposing a research agenda for the study and modeling of reputation and authority across informal knowledge markets **(1244708, $179,594.00, 2013 – 2014).** **PI: Sorin Matei.** To develop a broad multi-disciplinary community of experts from the social sciences, computer sciences, and statistics focusing on researching expertise and reputation in social media and develop a data-intensive approach for research in this area (KredibleNet). It will create the community and capacity to design and build large scale data analysis and management infrastructure to engage the challenge of understanding how these new knowledge markets are shaped by social interactions and reputations built around functional roles.
Intellectual Merit – KridibleNet will shape the next generation of theoretical and analytic strategies needed for understanding how knowledge markets are influenced by social interactions and reputations. The community discussions will ensure that the infrastructure developed to fill the current conceptualization and measurement gaps, data management capabilities and analytic tools will provide as much benefit as possible to all the related fields in industry and the sciences; they will also likely give rise to new research synergies.
Broader Impacts - The tools that will be developed through this work will render the existing large databases amenable to analysis allowing scholars and practitioners to address a broad set of questions and gain valuable insights. The potential users of these tools, data, and ideas are quite widespread extending to multiple scholarly domains, policy communities, and industry partners. They will be made available publicly, so others may benefit from the results of this project to develop the next generation of "information gauges" that can help tomorrow's information consumers make smarter choices.

IIS: III: Small: Information Recommendation for Online Scientific Communities (1017837, $498,431.00, 2010 -2013). Co-PI – Michael McLennan. To overcome the limitations of existing recommendation solutions with a new integrated information recommendation framework for online scientific communities.
Intellectual Merit – The proposed research will yield substantial benefits in broad areas. The information recommendation tool will be incorporated into nanoHUB to benefit a large number of users. The source code of proposed algorithms will be released with the HUBzero platform to enable further advance and development in information recommendation. The proposed information recommendation solutions can be adapted and used in other general purpose social network applications like LinkedIn/Facebook.
Broader Impacts - The PIs will encourage the involvement of underrepresented students in the research project. (Fang et al, 2010.)

B. Project Design

The cyberinfrastructure for Ripple will be STEM-EdHub.org (DLRC), a science education gateway built on the HUBzero® Platform for Scientific Collaboration (HUBzero). The precursor to the HUBzero architecture was nanoHub.org (NCN), which was established in 2002 with NSF funding and is operated by the Network for Computational Nanotechnology (NCN) at Purdue University. A HUB combines unique middleware with Web 2.0 functionality that facilitates public participation with content.

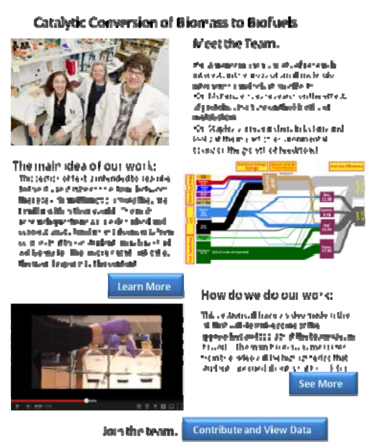
The growing use of the HUBzero-powered nanoHUB.org indicates that this infrastructure is indeed a nucleus for developing and supporting communities of practice, which benefit from economies of scale. In 2011, nanoHUB.org served 397,000 visitors from 172 countries worldwide. Of these, a core audience of more than 192,000 users watched seminars, downloaded podcasts and other educational materials, and accessed more than 230 nanotechnology simulation tools for both research and educational purposes (see image). nanoHUB.org has users at all of the Top 50 U.S. engineering schools (as identified by U.S. News and World Reports).



In 2007, HUBzero was spun out from nanoHUB.org as a separate project and software package to power new hubs. Today, HUBzero is a proven, dependable infrastructure that supports more than 40 hubs—including the STEMEdHub.org site which will form the backbone for Ripple—with a combined audience of 600,000 visitors each year. STEMEdHub.org is an online community of practice for STEM education researchers and practitioners. STEMEdHub.org launched on April 1, 2011, and has had more than 7,000 unique visitors since. While nanoHub.org was developed for an expert community, its collaborative nature is preserved in the HUBzero architecture and will support the goals of creating a social learning environment in Ripple.

Entry Portal and Pebbles

The entry portal to Ripple will provide users with thumbnails of featured topic pebbles, as well as a topic/keyword, discipline, or name (researcher or institution) searchable listing of all the pebbles. The portal will be open to anyone who is interested in exploring the content, though language used throughout will make it clear that students are the target audience. No account creation will be necessary to explore Ripple. However, users will be asked to set up a profile before they can contribute in the individual pebbles. This will allow each user to have an identity within the community, and will allow the contributions of that user to be aggregated for badge recognitions and searches.



Each research topic will be referred to as a pebble, and these areas will be the core of content sharing in Ripple. They will open with a standardized page design that presents the team, the main ideas of the research project and the methods used by the scientists. One or more key graphics will be included and a video showing the researchers' involved in their work and using the specialized tools of their discipline. These vignettes will be developed collaboratively by the researchers themselves and the student authors, ensuring not only accuracy of content but also appropriate level of presentation. The section introducing the main ideas of the work will describe to the students the connections between the research and things or issues they are familiar with in their world. The overall research questions will be described and connections to fundamental concepts from courses that these students may have had will be made. The "learn more" link will take the user deeper into the content. The video will include a descriptive text section that provides an overview of the main techniques and tools used. Users are encouraged to explore further with the "see more" button, which will lead to additional information about the process and methods. The opening page of the pebble invites the user to participate with a "join the team" link through which they can enter the interactive areas of the pebble for sharing and visualizing data or engaging in topic-related discussions with the community.

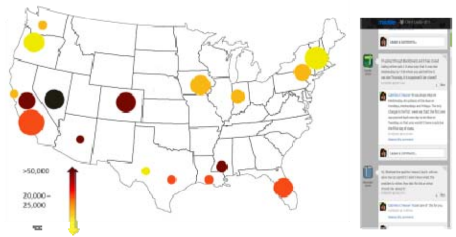
Pebbles will reflect ongoing interdisciplinary research projects, as illustrated by the following three projects, which have already expressed interest in contributing content to Ripple. They illustrate the range of basic science (biology, chemistry, physics, agriculture, mathematics) involved in cutting edge research and highlight its connections to real world challenges.

- **Direct Catalytic Conversion of Biomass to Biofuels**, led by Purdue professor Maureen McCann, is developing transformational knowledge and technologies to optimize the energy and carbon efficiencies of conversion of biomass to advanced biofuels and conducting fundamental research that will form the foundation of a renewable hydrocarbon industry. The project includes five partner institutions: Purdue, Argonne National Lab, the National Renewable Energy Lab, Northeastern University, and the University of Tennessee, that are collaborating on research that integrates plant genetics and molecular biology, cutting-edge catalytic and analytical chemistry, engineering and nanotechnology to directly convert non-food plant biomass to transportation fuels and other value-added products.
- **Glaciers and Climate Change.** Purdue Professor, Jon Harbor, is leading an international team (Purdue University, Stockholm University, Moscow State University, Peking University, Central Asian Institute of Applied Geosciences), that is reconstructing past glaciers and climate change across Central Asia. The well-constrained information they are collecting using field work, lab work and numerical modelling to reconstruct glacial histories, along with remote-sensing-based geologic mapping, and several geologic dating techniques on past special and temporal patterns of glacier change can then be used in testing global climate models and understanding the evolution of mountain landscapes.

- **Earthquake Engineering.** The Network for Earthquake Engineering Simulation (NEES), led by Purdue professor Julio Ramirez, focuses on accelerating innovations in infrastructure design and construction practices to minimize damage during earthquakes or tsunamis. Earthquake engineering researchers and students from fourteen universities across the country conduct advanced research on designs, materials, construction techniques and monitoring tools. Research results will enable engineers to develop better and more cost-effective ways of mitigating earthquake damage.

Participation: Discussing, Contributing Data and Using Simulation or Visualization Tools
Research shows that as interaction increases, sites become self-sustaining (Tapscott & Williams, 2007; Kittur & Kraut, 2008). Therefore, providing appropriate tools to engage the users will be an important focus of our design and development work. Like other social networking sites, Ripple users will be able to collaborate privately in groups and share information. They will also be able to publish resources and information that they generate, as well as test hypotheses with interactive simulation and modeling tools published by the researchers. The interactive tools look like simple Java applets, but are powered by a sophisticated cyberinfrastructure and run transparently in 'a scientific computing cloud that taps into

Purdue University and national grid resources' (HUBzero). They are easy to launch and include integrated visualization, so users can engage them with very little instruction.



The interactive tools will include researcher-generated databases to which users can upload data that they gather themselves. The data are then part of the public domain of the research project and the Ripple community can visualize and discuss the information in real time. One hypothetical example is shown in this figure, where dots represent the locations from where users have provided data, the size of each dot represents the number of users in that area that have contributed data, and the color of each dot is related to the variable being collected (i.e the average numerical value of the data). A discussion stream accompanies the real-time visualization of the data, allowing users to comment and pose questions.

To facilitate participation, Ripple users will acquire points for participation based on a system already in place on HUBzero. We will develop algorithms for awarding points based on level of activity combined with star ratings (see below). For example, a user can earn points by submitting a question, commenting on research material, answering a question, running a science simulation, or submitting data to a project, among other activities. Following other successful social media tools, we will devise incentives for participation that may include such things as a Citizen Scientist badge. As the site participation grows, "functional roles" will emerge. Some users will fulfill content leadership roles, as is common in social forums. Leaders will be followed and supported by the users through a 5-star rating system where users can rate contributions for their relevance and helpfulness.

We will also drive participation on the hub through proven methods of engagement including both strong tie (i.e. content sharing with friends, personal identification of one's online profile with specific communities of interest, and self expression) and weak tie activities (i.e. the ability to send messages to the group, make new acquaintances, and view others' content). Messaging and other mobilizing information we promote on the hub (and about the hub on relevant sites) will highlight the social and personal benefits of participation, to tap into user interest

C. Project Management Plan and Timeline

Ripple will be a collaboration among the Discovery Learning Research Center (DLRC), Instructional Technology at Purdue (ITaP), the Brian Lamb School of Communication and Purdue Libraries. The Director of DLRC will serve as PI on the Ripple project. She is a chemist by training with a long-standing research focus in science education. The DLRC is a research center dedicated to transforming education at all levels based on researched best-practices. It is one of eight core centers at Purdue's Discovery Park, which is an interdisciplinary cadre of facilities and experts that operates across all colleges of the institution. ITaP is the home of the programming team that is responsible for the HUBzero platform. The Brian Lamb School of Communication features faculty and resources with expertise in communicative engagement, social media and technology, media production, and communication management. The Director of the Purdue University Press, a unit within the Purdue University Libraries, is a co-PI on the project. He coordinates the Journal of Purdue Undergraduate Research and oversees the student editorial board for that journal. This multidisciplinary expert team will design and develop the Ripple platform and begin engaging the user community.

STEMEdhub.org is housed within the DLRC and it hosts a number of STEM education communities that support, enhance, and extend STEM-Ed Hub. Several projects at DLRC are using STEMEdhub.org as a mechanism for building community between and among teachers and researchers. These projects provide proof of concept showing the use of HUB technology to develop communities of practice as both valid and valuable. The project manager for STEM-Ed Hub will serve as senior personnel on the Ripple project and will coordinate design and development efforts.

As a pathways project, our goals are to develop the platform, engage in initial testing, and begin to engage the user base. Because some of the infrastructure for Ripple is already in place (STEM-Ed Hub, student editorial board for JPUR, DOI tools for Hub publications, collaborations with researchers interested in contributing pebbles), we believe that some of the early tasks of the project can begin to be accomplished before being notified about funding. The bulk of the work will then begin in the third quarter of the first year after submission of this proposal, and take place over the following year. It is necessary to carry out initial testing with a pilot group as development is taking place (alpha version), therefore that part of the process will also take place within that year. We thus envision this pathways project taking place over an 18-month period as shown schematically in the following table.

	Yr1				**Yr2**	
Project tasks	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**
Platform						
develop template (alpha) for scientist contribution	■					
develop DOI tools for contribution publication	■					
develop entry portal for users		■				
develop/revise interaction tools			■	■		
develop/revise data submission/visualization tools			■	■		
revise template (to beta version)					■	
revise template to "roll-out" version including DOI integration						
revise to v2.0						
Contribution						
alpha test of pebble submission (2 modules to test format)		■	■			
coordinate student editorial model	■	■		■	■	
develop recruitment model/materials for contributors			■			
use recruitment model for beta test contributors				■		
beta test of pebble submission					■	■
roll-out: invite broader group to submit pebbles						
Engagement						
Recruit pilot test group				■		
Pilot group test of alpha pebbles					■	
develop recruitment model			■	■		
Pilot group test of beta pebbles						■
Revise/refine recruitment model					■	
roll-out recruitment of users for broad use						
Measurement						
develop measures of usability		■	■			
apply usability measures				■		
develop measures of learning and engagement			■	■		
apply measures of learning and engagement					■	■
develop measures of interaction (quan and qual)				■	■	
apply measures of interaction					■	■

D. Assessment

Our assessment plan has both short-term and long-term aspects to it. During the pathways project, we intend to study the functionality and usability of the beta version of Ripple, and also to gather data for formative purposes regarding each of the project goals and each of the stakeholder groups. The formative data will be used in two ways – to further revise and develop the platform for a full development, and to develop appropriate assessment tools that will allow us to continue gathering data once the site if fully operational. As is the case with assessment in many informal learning settings, there are some challenges inherent in trying to gather data from an anonymous, transient and geographically distributed user base. However, the social networking and online aspects of Ripple provide a particular advantage for some forms of data gathering, namely analytics and discourse analysis. As described in detail below, these techniques will be used during the pathways assessment in combination with other forms of data collection (pre/post instruments, interviews, etc.), but will be the primary form of data collection once Ripple is fully operational.

The activities and outcomes of the pathways Ripple project are described in the following table. Details about measurement of various outcomes follow the table.

Related Project Goal	Inputs and Activities	Outputs	Outcomes
1. Develop beta version	Design and IT teams - Platform design and programming	Beta version of Ripple	Site is usable by contributors and users in order to create, share and view content
2. Mutual-benefit model for contribution	STEM Researchers Contribute content	Pebbles with passive content and Interaction tools	•Broad dissemination of research •New citable work
2. Mutual-benefit model for contribution	Interact with users	Two-directional exchange of ideas and expertise	•Broad dissemination of research •Generation of new ideas or directions for research
2. Mutual-benefit model for contribution	Gather user-generated data	Contributions to ongoing research	Influences direction of research or writing of publications.
3. User participation model	Pilot group of student users test Ripple	Data contributed, simulations run and discussion posts made.	•Students interact with other users and with researchers •Weakness and strengths of the platform design are identified.
4. Assess usability	Pilot group of students and research contributors engage in interviews and usability testing	•Self-report data about the experience of the users, both from contributors and students. •Eye-tracking information about how the site is used. •Quantitative analytics of site usage.	•Analyzed data will inform revision of the platform •Data collection will inform design of broad-scale assessment for full roll-out of Ripple platform
5. Learning along the six-strands	See narrative below for additional details		
5. Development of social learning community	See narrative below for additional details		

Assess Pathways Outcomes for Goals 1-4

As a pathways project, we plan to assess the progress that this work will make in establishing the foundation for fuller development of Ripple in the future. Accordingly each of the first four pathways project goals will be assessed (the fifth being the assessment goal):

1. Develop a beta version of the environment that includes two pebbles and user interaction tools.

   We will begin testing use of the site with a recruited pilot group of students from local high schools and Purdue, as well as two research teams who will provide the first two pebbles. Usability of the site by the pilot user group will involve inbuilt data collection systems such as Google analytics to look at metrics such as # of visitors, # of posts, average # of posts per visitor, amount of time spent, # of questions per visitor. For more qualitative information we will conduct focus group sessions with the pilot group. We will solicit information about site layout, organization and interest in the material and use eye tracking technology to gain a better understanding of how design elements impact participant use of the platform.

2. Establish the framework for a "mutual benefit" model for contributions by scientists that will enhance their research while also informing the user base.

   We will conduct interviews with the contributing researchers to assess their use of the site and of the usefulness of the data and discussions generated. Input from this initial group will then be used to generate revisions for the next set of pebbles that will be used in beta testing at the end of year 1. An indicator of this goal will be use by contributors who are not in the original development group.

3. Develop the framework for a user participation model that will be self-propagating.

   Interviews with student users regarding their engagement experience will allow us to revise Ripple and to develop recruitment models that are most effective.

4. Assess the usability of the beta environment and utilize those results for a revision plan.

   Site analytics, interviews and focus groups with users and contributors and eye-tracking studies will provide various forms of data for assessing usability.

Assess Six Strands of Informal Science Learning (Goal 5)

We will begin to develop measures to assess the six strands of informal learning. These measures will be designed to be applicable once a fully functional version of Ripple exists, and data are mined from user interactions with the platform.

1. Sparking interest and excitement.

   With the pilot user group, we will gauge interest in the topic areas both through focus group discussions and through pre/post self-report instruments about the topic areas. With the full Ripple user base we will rely on two indirect measures of interest: discourse analysis of user posts to the site discussion areas and quantitative measures of use (# of times returning to the site, # of contributions, amount of time at the site.)

2. Understanding scientific content and knowledge.

With the pilot user group we will utilize pre/post tests regarding the content of each topic. With the full Ripple user base we will rely on discourse analysis to determine the accuracy and quality of statements made about the scientific content and the appropriate use of scientific language. We will also examine, in the aggregate, the quality of the data being contributed by the user base.

3. Engaging in scientific reasoning.

   With the pilot user group we will monitor their use of the simulation and visualization tools with eye tracking equipment along with recording their contributed posts to see if they are using these tools to explore the scientific concepts they are intended to portray. With the full Ripple user base we will look at the aggregated results of running simulations to examine the types of experiments that users are carrying out with them. With both user groups we will also use discourse analysis to look for examples of scientific reasoning (e.g. hypothesis formulation, predicting, using evidence to develop explanations and to support claims) among the user posts.

4. Reflecting on Science.

   With the pilot user group we will depend on the focus group interviews to probe students' understanding of the ways in which scientists engage in generating scientific knowledge. We will probe along the dimensions identified by Driver, et al., (Driver, Leach, Millar, & Scott, 1996) to gauge whether students are reasoning about science with respect to phenomena, relationships or models. With the full Ripple user base we will depend on discourse analysis to examine user posts for any indications of the above.

5. Using the Tools and Language of Science.

   With both the pilot user group and the full Ripple user base we will employ discourse analysis to examine user posts for extent and appropriateness of use of scientific language. We will also log the numbers of times that students use the simulation and visualization tools.

6. Identifying with the Scientific Enterprise.

   Because this strand involves personal identity as part of the community, our analyses of the interconnections among the community of users will help us understand the degree to which the user base is identifying with the scientific enterprise. The emergence of leaders and their support by followers will help us understand if the community sees itself as an important contributor to the work or simply a consumer of knowledge.

Assess Six Strands of Informal Science Learning (Goal 5)
To ascertain the emergence of learning communities we will develop metrics that include community entropy and leadership scores, which rate the social dynamics within each community. We can define specific thresholds of participation and community aggregation using entropy (Matei, 2010). This will enable us to begin to answer the questions: What are the best strategies to drive engagement? How do Ripple groups self-moderate and achieve stability? How do social structures develop and influence learning within Ripple? Finally, we will use network analysis to assess if Ripple has facilitated communities of practice to form across classical academic domains (across pebbles and self-reported academic interests of the users

Assess Student Author Experience
An additional group that we will assess is the student author group who will serve in an editorial role. We will use pre/post surveys and periodic interviews to gauge the extent to which their participation is increasing their learning along the six strands listed above, and also if there are additional benefits along other areas, such as team work and general communication skills.

Long-term Assessment Planning
A final aspect of our assessment effort *during* the pathways project is to develop the techniques and tools that we will use to assess the use of a fully-developed site. Such an assessment will have special requirements because of the geographically distributed and somewhat anonymous nature of the subjects. Additionally, we will be unable to depend on traditional participatory methods of assessment (surveys, interviews). For this reason, an assessment consultant will be engaged during the pathways project to work with the assessment team on long-term assessment planning. The consultant has extensive experience with the evaluation of interactive instructional technologies.

E. Broader impacts

Ripple will provide researchers in science and engineering the opportunity to share their work directly with a non-expert audience. They will be able to use the platform to disseminate their work and have that contribution archived and referenced as scholarly work. Having Ripple users contribute data, ideas, and questions may help to drive the research work forward. Ripple will provide students with a source of scientifically trustworthy and vetted information that is targeted to their level of interest and understanding. Ripple will facilitate more than just learning about science, it will engage learners in doing science as they are able to contribute to real research. As such, we hope that it will increase user understanding of and interest in specific science content as well as enhance general, science process knowledge.

In its fully developed state, we envision that Ripple will assist in the development of strategic insight for the growing phenomenon of digital engagement, allowing us to gather information about online participation drivers and develop best practices for digital engagement and participation. This will benefit all online informal science learning efforts, even those associated with museum exhibits, since the social learning dimension could be extended to improve those experiences.

On a broader scale, Ripple will contribute a citizen science venue for use by the public at large. This will increase public awareness of the processes and tools of science and of the nature of scientific knowledge. By encouraging broad participating in a non-expert scientific community, Ripple will contribute to increasing public scientific literacy, which is crucial for anyone who is a concerned citizen of the world.

Dissemination
Dissemination of Ripple will take place using online and social media venues to broadcast the location (Twitter, Facebook, web sites frequented by students). In addition to the Ripple platform itself being disseminated, we will disseminate information about the design, testing and use of Ripple through scholarly venues including publication in appropriate journals and presentations at conferences (both live and online).

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