(last updated April 2022)

STRATEGIC INITIATIVE D. Developing capacity in applying selected promising technologies

BRIEF DESCRIPTION - *FROM THE 2019 LiDA STRATEGIC PLAN*:
As new promising applications to education of specific technologies emerge, supporting those applications will require some basic understanding of the technology involved and its potential implications. Given our limited staff and rapid advances in technology, we will need to continue to strategically evaluate which technologies we want to focus on, and what it would take to develop sufficient internal capacity to support their use. At the moment, we have identified the greatest opportunity (and need for developing internal capacity) in Artificial Intelligence (AI) and Data Science – although we expect that new priorities will continue to emerge overtime.

*(NOTE: hereafter, * indicates LiDA staff, and ** indicates LiDA Community members)*

Our vision

This strategic initiative arose from the recognition that access to "big data" and advances in Artificial Intelligence (AI) technologies and applications are rapidly changing the world around us - in our daily lives as well as the workplace. And while education seems to be lagging behind, we can assume that expectations about how future workers should be prepared will also change soon; furthermore, new applications of AI and data science may suggest innovative ways to support and enhance learning that we may not even be able to envision today.

Evidence of these developments can be seen first of all in the increasing amount of federal funding devoted to applications of AI that may have relevance for education - including most notably grant programs within the National Science Foundation (NSF) such as Future of Work at the Human-Technology Frontier program, cybersecurity education, or Research on Emerging Technologies for Teaching and Learning (RETTL). Additional evidence can also be found in the New York State Education Department's (NYSED) decision to create a new set of K-12 learning standards for Computer Science and Digital Fluency - which were first issued in draft form for comments in 2019, and then released in their final form in December 2020. While adoption of these standards has been somewhat delayed by the pandemic, NYSED's commitment to implement these new standards is evident in their decision to release two new grant programs to fund related teacher professional development - the 2021-26 "Smart Start" grants for K-8 schools, and a new round of 2021-24 Learning Technology grants.

Not surprisingly, positioning the LiDA Center as a key player in this new field emerged as a top priority during our 2019 strategic planning process. Yet we also realized that achieving this goal would present some unique challenges for our Center - as while our LiDA staff has developed considerable expertise in online and digitally-rich teaching and learning over the past decade, we do not have any expert in computer science and/or data science on staff. This led us to identify as a first critical step the need to develop capacity to do this kind of work - through a combination of our staff's commitment to learn about these fields, training some doctoral students to develop a dual expertise, and partnering with experts.

As we started moving in this direction, we were pleasantly surprised to discover that our expertise in education and innovation, combined with our prior experiences working at the intersection of different fields, made us immediately valuable as members of

interdisciplinary teams operating in this field - despite our limited knowledge of the technologies involved. This led us to seek - and secure - grant funding earlier than initially expected.

Efforts towards building capacity to date

As mentioned earlier, we approached the challenge of building capacity for work at the intersection of AI/Data Science and education in three complementary ways.

Developing LiDA staff's expertise in selected technologies*:* Some of our staff members have been investing significant effort in learning more about these new fields - even though this often required them to go beyond their "comfort zone"! In Spring 2020, *Borasi and *Borys completed a semester-long course on "Artificial Intelligence Explorations and Their Practical Uses in Schools" offered by the International Society for Technology in Education (ISTE). In addition, *Borasi, *Borys and *Miller have been attending many webinars and presentations about potentially relevant applications of the targeted technologies - as made available through UR events, conferences, or on the Internet. Notable examples have included presentations that took place within the following events:

- Rochester Institute for Technology (RIT) Annual Frameless Symposium (2020)
- Audio-Engineering Society (AES) Virtual Symposium: Applications of Machine Learning in Audio (2020)
- New York State Society for Computers and Technologies in Education (NYSCATE) Annual Conferences: Game Changer (2019) and Reflect, Rejuvenate, Redefine (2020)
- Arizona State University and Global Silicon Valley (ASU/GSV) Virtual Summit (2020)
- Stanford University's Human-Centered Artificial Intelligence (HAI): COVID-19 and AI: A Virtual Conference (2020)

However, the most productive vehicle to learn about new technology fields and application, by far, has been engaging in collaborative interdisciplinary projects that "forced" LiDA staff to learn "enough" about other fields to be able to communicate and collaborate with experts in those fields in the team - as described in more details later.

Developing and leveraging doctoral students' dual expertise*:* We have also been proactively recruiting doctoral students interested in working at the intersection of education and AI/DS, and encouraged them to pursue the Advanced Certificate in Data Science offered by the UR College of Arts and Sciences - or at least take some courses in those areas. Three of our current doctoral students (**Erqian Xu, **Qinqin Xiao, and xx) started to take courses as part of the Advanced Certificate in Data Science program in Summer 2021, and have almost completed their program. **Xu and **Xiao have also been accepted in a special NSF-funded training program in AR/VR. We also recently admitted two doctoral students that already come in with some background in data science (Elham Tajik and Abeer Alshehri).

Partnering with experts: The following collaborations – which mostly occurred in the context of developing specific grant proposals – with colleagues who are experts in the targeted technology areas, both within the UR and beyond, have been most productive both for securing the needed expertise we did not have in house, and to continue to develop our own internal capacity to engage in this kind of interdisciplinary work:

- A collaboration involving **Dr. Zhen Bai, Assistant Professor in Computer Science, and *Borasi, *Miller and **Daley, around possible ***applications of machine learning to***

students' scientific inquiry has been going on since early 2019. So far, this collaboration has centered on enhancing and developing educational applications for a novel computer-operated learning environment, *Smiley Clusters*, created by **Bai and her doctoral students to scaffold the use of selected machine learning algorithms to make sense of large set of scientific data and invite the generation and testing of hypotheses. To date, three grant proposals were developed and submitted to NSF Computer Science program in May 2019, IES in February 2021, NSF RETTL program in October 2021, and two submissions were made to the University Research Award program (2020 and 2021). While none of these proposals have yet been funded, we have been invited by the RETTL program officer to submit an EAGER grant proposal in March 2022 (currently pending). Our work towards these proposals has contributed to **Bai's development and piloting of her envisioned software and led to a few presentations and publications, including a presentation as part of the UR Data Science Series in Fall 2019 and a 2022 book chapter, both co-authored by **Daley, **Bai, *Borasi and *Miller. But even more importantly, this work generated valuable learning for everyone on the team - most notably providing a deeper understanding of machine learning and its potential applications in education for *Borasi and *Miller, which has informed other work.

- *Borasi and **Daley were also involved in a university-wide effort to apply for an ***NSF AI Institute on AI-Augmented Learning*** - a very ambitious undertaking, given that only 6-7 such Institutes have been funded each year for several million dollars each. A first proposal for a planning grant was submitted in January 2020; while denied, the planning meetings we participated in were instrumental to develop connections with faculty from across the UR interested in AI-augmented learning and other applications of AI to education - which in turn led to the next initiative.

- The connections developed during the AI Institute application process, combined with a call for proposals by the NSF Future of Work at the Human-Technology Frontier program, suggested the value of applying for an internal University Research Award [URA] to ***develop capacity in the Future of Work area within the UR,*** so as to be able to submit more competitive grant proposals in the future. A team of 16 faculty and staff from several Centers and almost all academic units within the UR, led by *Borasi, participated in this effort and submitted a first application in February 2020 - when the program was cancelled because of the pandemic. A subset of this team also decided to apply in March 2020 for a Future of Work planning grant focusing on the Artist-Technologist occupation - which was awarded and is described in the next section among the "funded projects". A revised and enhanced URA application was submitted when the program was reinstated in early 2021, involving an even larger 25-people team; while a URA was not awarded, we were still able to launch a slightly modified version of this project in Fall 2021 with funding contributed by the several units involved in the project – as also reported in more detail the next section.

- Shortly after we were awarded the Future of Work planning grant, a team of junior professors from computer science and engineering from RIT contacted *Borasi for a potential collaboration - as they had also applied for a Future of Work planning grant that was declined, and the reviewers had pointed out as a major weakness that their team did not include any educator. The RIT team and a LiDA team including *Borasi, *Borys and Qinqin Xiao, a Warner doctoral student, met weekly for about six months

to develop a $2.5M Future of Work research grant proposal around identifying expert machinists' tacit knowledge and ***designing AI-powered learning experiences to help novice machinists effectively develop such knowledge*** *(see the proposal summary submitted to NSF for a brief description of this project)*. While this proposal was declined, the team learned a lot about preparing a full-fledge Future of Work research grant, and built on this experience when preparing another Future of Work proposal the following year, as part of the NSF-funded planning grant on "artist-technologies", described in the next section.

- The LiDA Center was approached in Spring 2020 by another RIT faculty member, Peizhao Hu, who was seeking education partners to apply for a special NSF call for proposals at the intersection of cybersecurity, AI and education. While this initial proposal was not funded, the program officer encouraged submitting a revised proposal for a regular grant in ***cybersecurity education***. The team, comprising of Hu and Dana Dachman-Soled from the University of Maryland as experts in cybersecurity, and *Borasi and *Borys, as experts in mathematics education, met weekly during the 2020-21 academic year to develop a proposal for a new type of introductory course to cybersecurity at the undergraduate level. An important part of this experience required *Borasi and *Borys to learn about cybersecurity methods such as Multi-Party Computation (MPC), in order to make meaningful contributions to the design of the proposed course. This collaboration was unfortunately stopped by Hu's departure from Rochester. However, it provided *Borasi and *Borys the confidence to accept the invitation to participate in a different grant proposal on cybersecurity education initiated by RIT faculty Jay Yang and Justin Pelletier in late 2021. This proposal, which focuses on the design and study of a dual-track professional learning program for cybersecurity engineers and analysts to learn about AI/ML applications through role-playing, will be shortly submitted to NSF in May 2022.

- In Fall 2020, Warner Dean Peyre and Engineering Dean Heinzelman facilitated a connection with Dr. Cesare Wright, the founder and president of the Kyno-Eye Center, because of his unique combination of expertise in engineering and film-making, and his experience designing innovative technology experiences for students as part of programs funded from Microsoft. *Borasi, *Borys and *Miller have been exploring possible collaborations with Dr. Wright in a few Zoom conversations, which eventually lead to partnering in the development of computer science "experiences-as-learners" for K-12 teachers for one of the state grants described in the next section.

It is worth noting that, although most of the grant proposals we submitted so far have not yet been funded, they have proved to be very rich opportunities for LiDA staff and RAs to learn about AI/data science and its possible applications to education, as well as to develop long-term relationships with colleagues in other fields that will prove very beneficial as we continue to grow our expertise.

These invitations to join working groups and grant applications are per-se a concrete recognition of the increased capacity of LiDA staff to engage in work at the intersection of education and AI/DS. Another form of recognition has come with the invitation to *Borasi to join the UR Goergen Institute for Data Science (GIDS) as an affiliated faculty in Fall 2020, and then to serve on the GIDS Director's Advisory in 2021.

Funded projects

The collaborations and learning described in the previous section have led to a few funded projects the LiDA Center has already been able to secure to date.

Future of Work planning grant exploring the Artist-Technologist occupation: This 1.5-year $150,000 planning grant from the National Science Foundation [NSF] has supported the exploratory work of an interdisciplinary team of 21 UR and RIT faculty and staff around artist-technologists' creative design at the human-technology frontier - with an initial focus on music (as the artistic domain) and Artificial Intelligence and Augmented/Virtual Reality (as main technologies) (see public abstract). The project core team included *Borasi (as PI), *Borys, *Miller and Warner doctoral student **Erqian Xu. In addition to the cross-disciplinary learning acquired as the result of presentations from various experts on the team, project project activities have contributed new insights about what and how individuals who are not expert in technology needs to learn about cutting-edge technologies in order to be able to leverage them for their work and to effectively collaborate with technologists who can complement their domain expertise – as summarized in a 3-minute video presented at the 2022 STEM for All Video Showcase, and also reported in the "Insights" section of the website we created with "Resources for Future Artist-Technologists".

UR Future of Work Capacity Building project: With internal seed funding provided by the Warner School of Education, the Goergen Institute for Data Science and the Ain Center for Entrepreneurship, we were able to launch in Fall 2021 a pilot project to develop interdisciplinary teams with the capacity to conduct research on the implications of AI and Data Science for preparing future professionals in specific fields. For the 2021-22 academic year, new Working Groups were established for Health Care, Humanities, Climate Economy and Higher Education Student Services. The latter group also collaborated with the Ain Center to offer a day-long "Collision Challenge" event for UR students, where eams tackled some specific challenges in UR student services and suggested possible solutions that leveraged AI.

Computer Science strand of the Wayne-Finger-Lakes BOCES NYS Smart Start grant: **The** The LiDA Center, in collaboration with the Center for Professional Development and Education Reform and Dr. Cesare Wright (Kino-EyeCenter), has designed a year-long fully-online professional development program for K-8 teachers participating in a 2021-2026 "Smart Start" grant awarded to the Wayne-Finger-Lakes BOCES. This 5-year grant, aiming to develop capacity to implement the new NYS Computer Science and Digital Fluency Standards, will serve each year a group of 50-60 K-8 teachers. All participating teachers will engage in the equivalent of a 3-day Summer Institute plus two additional 2.5 hour Zoom sessions during the year; a sub-group of these teachers ("Tier 2") will also attend two additional Zoom session and participate in a mentored Professional Learning Communities (PLC) to support the implementation of what they learned into their classes. A first offering of this program has been completed for the 2021-22 year, and turned out to be a great learning experience not only for the participating teachers, but also all the facilitators!