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COMMENTARY

Developer meets developmentalist: improving industry–research partnerships in children's educational technology

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Today, fully 98% of children under eight have access to a mobile device at home (Rideout, 2017). Not surprisingly, researchers are increasingly interested in studying development in the context of these new technologies. But there are barriers, including the rapid pace of change and the expertise required to develop software to be used in research. We propose that successful partnerships between developmentalists and developers are crucial for rigorous research on children's digital technology. We focus on the need for researchers to partner with developers during the research process. For example, researchers might want to create and test an educational game or evaluate how different game features might promote learning, both of which require industry partnership. Some categories of research, such as testing a commercial product or examining the impact of digital media on parent–child interactions, may not require developer input, but for any research questions, industry collaboration is vital. We provide guideposts for researchers interested in establishing research–industry partnerships based on lessons learned from our own experiences and from having one of our own (BV) join the educational technology world. These suggestions are followed by recommendations on how the field can foster stronger partnerships.

When developing research–industry partnerships, researchers must understand the developer's perspective. Though academics need developers for technical expertise in creating digital products for research, developers have fewer compelling reasons to partner with academics. The primary motivator for developers is to create a product that will be competitive in the marketplace.

Accordingly, developmentalists can make themselves useful to developers by providing information about the effectiveness of their products. This useful information comes in two forms – evaluative research evaluates a commercially available product, while formative research helps developers build a product based on scientific evidence and test its efficacy. The reality however, is that data collection, especially with children, is a lengthy process. Even producing preliminary reports can occur on such an extended timeline that results are no longer helpful for improving or marketing the product. For example, in one of our collaborations, over a year passed between when we initially received the game and when we

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provided the company with data about its educational effectiveness. Though the data still had some value, a year is a long time in the tech world. In hindsight, we realized that providing data faster, even if informally and qualitatively, could have yielded more benefits for our industry partner.

Guideposts for researchers interested in partnerships with developers

These guideposts, which we wish we had known when initiating our partnerships, suggest ways to address common misunderstandings. The Appendix 1 contains a set of questions to consider in establishing partnerships.

Guidepost 1: find the right professional and recognize their expertise

First, hiring a professional developer is invaluable. For one app we needed to have built for a study, we spent a year working with undergraduates supervised loosely by a computer science faculty member. The price seemed great and at first so did the progress. But over time it became clear that the students' skills were not sophisticated enough for what we needed. We ended up starting over from scratch, costing us both time and money.

Excellent developers do not need to advertise; finding them requires detective work. But academic and industry professionals do not typically mingle at the same conferences, so how do we kindle these relationships? One possibility is seeking references from research colleagues who have created apps. Connecting can also happen at events like the *Games for Change Festival,* the *Dust or Magic Institute, and the Children's Global Media Summit.* Special meetings are also proliferating, like the *Technology and Media in Children's Development Conference by the Society for Research in Child Development* or the *International Communication Association's preconference on Invention and Intervention: Blending Research with Practice to Develop Effective Media for Youth.*

When interacting with potential partners, consider the mission of their organization. In one of our partnerships, we found a company whose explicit goal was to "blend technology, learning science, and design to create engaging and effective educational experiences" (http://smartypal.com/). Our collaboration was based on the idea that the experimental data we generated from the partnership would inform product designs. We advise researchers to reach out to like-minded developers and work with them using science to inform product development. Conversely, ensure that the developer is not hoping to use your prized endorsement to help sell a product with little relationship to the evidence.

In the Appendix 1 under Guidepost 1, we have listed several questions researchers should consider about the company's background and experience. For complex projects, enlist a technology consultant who knows the relevant questions a researcher might never think to ask, perhaps someone from Information Technology or your university's computer science department.

If a researcher has identified the right developer, recognize, and acknowledge their expertise. Seasoned developers should have a keen sense for user experience and what children will or will not respond to. Their expertise can be a boon to developing an app for research.

Guidepost 2: quality collaboration does not come cheap

Do not underestimate the time, skills, and funds required to complete the project. Even with firm target deadlines, unexpected issues can delay progress. Be prepared for the project to take at least twice as much time as you think and consider setting a price for the job rather than paying an hourly rate. In their typical work, developers often release imperfect products and fix bugs in subsequent updates, a process that can extend for years. But researchers need a smooth-running product before beginning data collection so all participants have the same experience, and to minimize the risk of data loss. Even with a seemingly final product, operating system upgrades and other unexpected bugs may arise. Make sure to budget for ongoing maintenance.

The primary way to fund these partnerships is building the real cost into grants, which may mean reducing the budget in other categories and proposing projects with fewer studies. However, our experience is that funding agencies like the US government's Institute of Education Sciences and the National Science Foundation seem to appreciate these costs and are willing to approve appropriately large budgets. Continuing to provide feedback to grant agencies about the true costs associated with app development will help ensure this trend continues.

We encourage readers to research and anticipate these costs and we provide suggestions for establishing these costs in the Appendix 1 under Guidepost 2. Most developers are not interested in barter and are generally not enticed by a new and improved app to test a research hypothesis. Before making any commitments check with your university's lawyers about who will own the product. Sometimes researchers do not technically own the software from funded research, and therefore, cannot give it away.

Guidepost 3: establish expectations and write a contract

As a partnership begins, expectations must be established for timelines, finances, and final products. This initial step, which often comes prior to funding, is incredibly important, requires significant effort, and may be a drain on developer time without clear economic payoff. In the Appendix 1, under Guidepost 3, we included a checklist for setting expectations within new partnerships.

Once both parties agree on product scope and confirm funding, expectations should be outlined in a contract. Contracts should include brief descriptions of the final product, the financial agreement, and expectations for data collection, data sharing, publication authors and recognition, ownership rights, confidentiality requirements, liability, and contract termination procedures. When outlining the contract, consider worst case scenarios. For example, what if the company changes their business model or dissolves the business prior to the conclusion of the study? Would data collection be interrupted if the digital platform disappeared? Most universities have lawyers who can review contracts and some have tech ownership clauses you should make sure you understand.

Throughout the development process, user testing should come early, often, and be accompanied by frequent discussions about possible changes. Clear feedback to industry partners should be communicated in a timely manner. Sometimes the ideal changes will require a much greater investment of time and money than is justified. Other times the changes are necessary and cannot be avoided. Regardless, discussing concerns earlier is

always better than later. Researchers may lack an understanding of the technical challenges associated with modifications; industry partners may not be clear on the importance of various features for the project. This stage of compromising can be a balancing act, but being honest and clear with partners will improve the end product without ballooning your budget.

Guidepost 4: clarity is key

The technical languages of our respective fields are laced with jargon, so do not assume everyone will understand and don't hesitate to ask clarifying questions. For example, in one of our partnerships, the word "assets" was used continually by the developers to refer to art and audio for the app. In another collaboration, we naturally used the terms "condition" and "order." Eventually both groups caught onto the lingo, but avoiding jargon and clearly defining terms can help reduce the mutual learning curve.

In addition to clarifying terms, clarity about the entire project is important. For experimental control, researchers often have precise requirements that developers may not realize are crucial. For example, controlling for exposure to definitions in a vocabulary game may require a particular structure of in-game responses for incorrect answers that would not be found in a commercially available game. Researchers usually have a general idea in mind for the final product, but that idea should be formalized into a "functional spec," including mock-ups and artwork. These specs provide a detailed list of critical features and requirements, which are then translated into a plan the developer can act on. Presenting sketches or animations can help both parties understand the vision for the final product. The alternative – unclear specification – will cost time and frustration in the long run.

One valuable way to improve clarity about the product is through strong communication. Meet in person or through video-conferencing as often as possible and set at least a bi-weekly call to discuss progress. Trust and commitment are easier to build through face-to-face communication rather than lengthy phone calls. In the Appendix 1 under Guidepost 4, we provide some questions to consider regarding this communication.

Recommendations for the future of the field

Next, we move to some suggestions intended for professional organizations and societies who want to move the children's media field forward and help foster fruitful collaborations.

Increase communication between developers and developmentalists

Regular meetings of researchers and industry professionals with aligned interests would be valuable for fostering partnerships. Some meetings are already happening but with more frequency they could provide a context for industry professionals to inform researchers about new technologies and for researchers to disseminate scientific information to industry professionals. To facilitate these interactions, industry members could be invited to join academic conference panels or give keynote addresses. Furthermore, organizations could waive fees for these "cross-pollinators." Finally, if we want developers to work with us, sharing our science in a digestible way is imperative. For example, Hirsh-Pasek et al. (2015) distilled some basic principles from the science of learning in a form that was accessible to those

outside of academia. Companies like Google and Amazon requested more information, as did several smaller start-ups. More of these translational efforts would be highly beneficial.

Develop a directory, listserv, or website

Currently no central hub exists for accessing information about developers interested in working with researchers, and researchers seeking developers. Such a centralized collection of information could offer samples of prior work and describe projects under construction. This directory could be developed by a society (e.g., International Communication Association, Society for Research in Child Development, or American Academy of Pediatrics) with collaboration from other leading industry organizations (e.g., Dubit, BBC-CBeebies, PBS KIDS, etc.). Alternatively, such a directory could be developed as part of a new hybrid organization formed to bring researchers and industry together. Support could come from researchers' university or grant funding, or from foundations and nonprofits with an interest in promoting the creation of evidence-based educational technology.

Establish developer positions at research institutions

Colleges and universities could establish full-time positions for dedicated developers within information technology centers. At the institutional level, this kind of office might be appealing because revenue for research-based apps would stay "in-house." For researchers, in-person meetings would be more feasible and competing demands from external clients would be minimized, making development more efficient. These positions could be partially or fully funded by allocating grant funding from researchers who use the service. For example, at the University of Wisconsin – Madison, researchers can partner with staff at the Teaching and Research Application Development office to create technology for projects. Finally, institutions could hire staff to establish partnerships with external developers and facilitate the process across departments. Some universities already have these services available, so check whether such local support exists at your institution before launching with an external developer.

Recognize products or organizations that integrate developmental science

The research community should recognize developers who successfully integrate the science into their products. Prominent professional organizations might consider offering an award for the best educational app or offering a scientific "seal of approval" that would incentivize the industry to pay attention to research. A few organizations currently have similar programs, like Children's Technology Review, but the award information is behind a paywall and is not readily accessible. However, researchers could partner with organizations like these or groups like Common Sense Media who already have established app review systems.

Future technologies

We focused here on app development, given our experience using tablets and mobile media in research. But technology changes rapidly and researchers are often behind the curve,

studying the last big fad as it peaks rather than looking ahead to the next innovation. New technologies, such as virtual reality, augmented reality, and artificial intelligence, are already beginning to affect children's lives and will require partnerships with industry. Our principles and recommendations apply broadly to both current app-based technology and to whatever comes next. Indeed, one potential advantage of industry and researchers working together is to forge partnerships ahead of the current trend.

Conclusion

Despite our optimism about the potential success of research–industry collaborations in our subdomain of educational technology, it is important to note that in other areas there are considerable competing motivations that may limit such partnerships. For example, social media sites are unlikely to want to partner with researchers to study how different features of their platforms affect adolescents' self-esteem, as results may reflect negatively on their platforms. Furthermore, industry has a powerful economic incentive to avoid partnering with researchers due to substantial points of disagreement over issues like privacy and commercialization. Lack of trust between partners on some of these issues can be barriers to successful collaboration.

However, we believe that in the field of educational technology, there is particular promise for many rewarding collaborations. Following the guideposts set forth here should help foster successful partnerships in which both developers and developmentalists feel respected for their important contributions to designing and understanding the impact of the next wave of technology development.

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Roberta Michnick Golinkoff, University of Delaware, has received numerous awards for her contributions to developmental science, including the 2017 Society for Research in Child Development's Distinguished Scientific Contributions Award. Funded by federal agencies and foundations, she has written 16 books/monographs and numerous research articles. She is passionate about disseminating psychological science. Her latest book (with Hirsh-Pasek) is *Becoming Brilliant: What Science Tells Us About Raising Successful Children*.

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Appendix 1. Checklist of items to consider in forging a research-industry partnership

Guidepost 1: Find the right professional and recognize their expertise

- What prior projects have they done?
- Can you contact other academics with whom they have worked?
- Ask to see examples of their work.
- What platforms do they typically develop for (i.e., iOS vs. Android)?

Guidepost 2: Quality collaboration does not come cheap

- Are there ways to structure the deal that may further align interests?
- Can you offer a bonus if the app is delivered by a specific date to motivate on-time delivery?
- If the app requires more development time than initially expected, how can these extensions be built into the contract?

Guidepost 3: Establish expectations and write a contract

- Break up the overall development task into smaller units. Develop a timeline that both parties agree to, including:
  - Detailed functional specifications
  - Alpha testing: Minimum viable product for user testing and bug discovery
  - Beta testing: Improved product to be tested in circumstances similar to final use; continued bug detection and correction
  - Final product deliverable
  - Ongoing support
    - Plan development time to manage compatibility issues that may arise due to OS changes and software upgrades
    - Assume you will find bugs that are not immediately evident
- Issues to consider
  - How will payment be structured (e.g., 50% up front and 50% on final delivery)?
  - Who owns the resulting intellectual property and under what circumstances or with what restrictions can it be used by the developer?
  - What limitations does final delivery place on using the software (e.g., will the source code be made available in a format that is editable by others)?
  - Does the developer want to collect or use data from app users or sell the app in the app store?
    - If so, what are the long-term expectations from the partnership with respect to data?
  - Do you or your industry partner want to protect your interests with non-disclosure agreements (NDAs)?
    - Ensure that an NDA does not limit your ability to publish.

Guidepost 4: Clarity is key

- Are there terms or acronyms the developers typically use that the researchers should be aware of? Are there terms the researchers use that the developers do not understand?
- What communication methods do they use with customers to ensure a successful relationship?
- Are they open to setting up a weekly or bi-weekly check-in?
- Aspects of user experience to discuss
  - How do you want the app to respond to the child's interaction?
  - Timing information between scenes/items
  - Will the app allow for changing settings to make it easier or harder?
- Materials that may be needed
  - Stimuli for the app:
    - Photos or digital artwork
    - Audio files
    - Videos

- Scoring information if performance measures are calculated
  - Master sheet explaining what each variable means
  - Spreadsheet of sample output
  - Document specifying item scoring, with samples
  - Any algorithms for calculating scores (i.e. sum across items, gain scores)