8-29-2018

Improving Undergraduate Engineering Students' Spatial Skills Through 3D Interactive Virtual and Physical Manipulatives

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Data Management Plan

This data management plan is developed based on the instruction by the "Data Management for NSF EHR Directorate Proposals and Awards" available at http://www.nsf.gov/bfa/dias/policy/dmpdocs/ehr.pdf The purpose of the plan is to address two main questions: What data are generated by the proposed project? What is the plan for managing the data?

Type of data that will be generated and shared with others

Two types of data will be generated over the course of the proposed project, including analyzed data and the metadata that defines how these data are generated. For sharing purposes, both types of data will be retained and made available for sharing with others in the community of interest.

Analyzed data

This group of data will primarily include:

1) Computer source code for manufacturing physical manipulatives via 3D printing technique as well as the online interactive computer program used to support VPM technology.
2) The raw digital data collected from student participants for investigating the effectiveness of the proposed 3D interactive virtual and physical manipulatives (VPM) technology on student learning outcomes. The raw data will include student demographics, students' scores in pretests and posttests, as well as corresponding statistical analysis, such as descriptive analysis, Analysis of Variance (ANOVA), Analysis of covariance (ANCOVA), correlation analysis, and factor analysis. The data will be in the form of tables and figures that document research results and findings.
3) The raw digital data collected through electroencephalography (EEG) while students are using VPM technology. The data, which measures neural efficiency, will be in the form of tables and figures that document research results and findings.
4) The raw digital data collected from video recording of student activities, questionnaire surveys, and semi-structured interviews to understand students' spatial thinking when using VPM technology. The data will be in the form of text transcripts, video files, tables and figures that document research results and findings.
5) The digital data generated from the formative and summative evaluation of the project regarding to what extent the project has met its goals, including the tables and figures that document evaluation results.

Metadata

This group of data will primarily include the document describe how the proposed 3D interactive virtual and physical manipulatives (VPM) technology can be used.

Period of data retention

The analyzed data and the metadata will be retained for at least three years after conclusion of the award, or three years after public release, whichever is later. Public release of the data – in the form of journal articles, conference presentations, free CDs and DVDs – will be made at the earliest reasonable time. For example, the data will be accessible immediately after publication.

Data formats and dissemination

The above-described analyzed data will be in various digital forms, including CDs, DVDs, and digital tables and figures that document the results of statistical analysis and research findings. The above-described metadata will be in the form of word documents. The policies for public access and sharing of the data include (but not limited to): 1) No public request can be made to connect the raw data with the names of individual student participants in order to protect the privacy and confidentiality of students. 2) No public request can be made for the analyzed data that is no longer retained by the PI beyond three years after the award.

The data will be shared with and broadly disseminated to the STEM education community. The ways in which the data will be disseminated are presented in the following paragraphs:

1) Broad communication network of the Spatial Intelligence and Learning Center: This NSF-funded Science of Learning Center (spatiallearning.org) aims to understand spatial learning and develop programs and technology to transform educational practices. We have connections with the Center's staff members and will disseminate the project results to the Center's Spatial Network, which includes more than 700 researchers, educators, and policymakers from a variety of institutions across the nation and around the world.
2) Direct dissemination to engineering educators and researchers via personal contacts and professional organizations: Through more than 15 years of efforts, we have established many personal contacts with a variety of higher education institutions across the nation. We will also contact relevant professional organizations, such as ASEE, SWE, SHPE, and NSBE, to reach STEM educators and researchers, including women and racial minority educators and researchers.
3) Internet dissemination: Selected project materials will be uploaded to the project website, popular education websites (e.g. aacu.org), social media (e.g., Youtube and Facebook), and open-access online digital libraries, such as the National Science Digital Library (NSDL).
4) Journal publications: We will target peer-reviewed and high-impact journals that focus on the development and research of innovative educational technology, such as Computers in Human Behavior, Journal of Educational Psychology, and Journal of Computer Assisted Learning.
5) Conference presentations: We will target spatial learning-focused conferences (e.g., Spatial Cognition, Spatial Learning for STEM conferences), educational technology-focused conferences (e.g., annual International Conference on Computer Supported Education), and engineering education conferences (e.g., ASEE and FIE annual conferences).
6) Special sessions and workshops: We plan to organize special sessions or workshops on spatial learning at selected conferences, not only to disseminate the project results, but also to seek constructive feedback in order to continuously improve the project. Free CDs and DVDs that contain the project materials will be disseminated to session/workshop attendees.

Data storage and preservation of access

All analyzed digital data and metadata will be stored in a password-protected computer in the PI's office. The raw data collected from student participants will be stored in a locked file cabinet in a locked room in the PI's office building. For safe storage of the raw data, only the PI has the key to the locked file cabinet.