InterLACE Worksheet

Samuel Heilbron[1]; John Spiva[1]; Samantha Welch[1]
Sponsors: Ethan Danahy, Research Assistant Professor[1,2]; Ean Wong, Education Technology Specialist[2]
[1] Tufts University Department of Computer Science, [2] Center for Engineering Education and Outreach

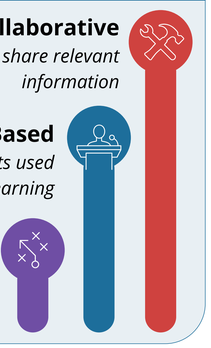
InterLACE[a] Philosophy

*Correlation between **collaborative**, **design-based**, **inquiry teaching** and strong student conceptual gains*[1,2]

Collaborative
Negotiate and share relevant information

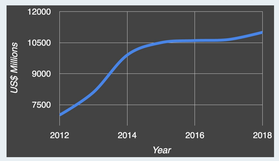
Design-Based
Real world contexts used to scaffold science learning

Inquiry
Teacher guides students through process of exploration



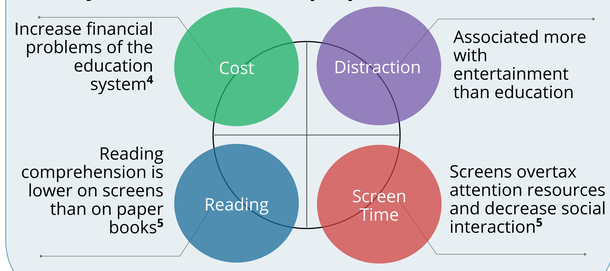
Education Technology

Global Education Technology Spending Trend on Mobile PCs[b] (2015)



Spending on classroom technologies, such as mobile PCs, has been rising dramatically, reaching a total of $15.2 billion in 2015.[3]

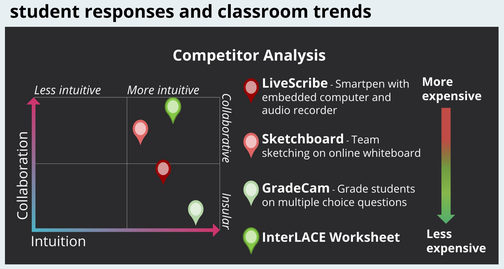
Why haven't iPads or laptops solved this issue?



Worksheets

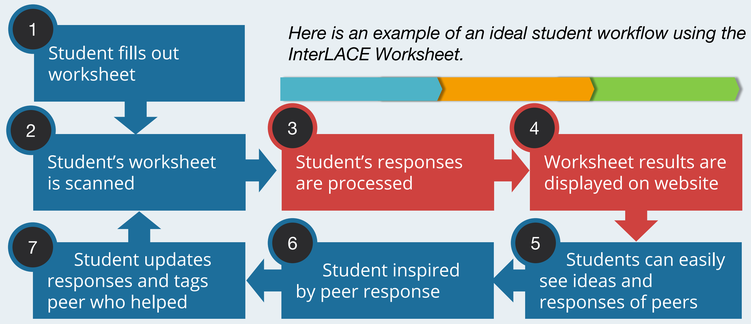
Worksheets are great! They are tactile, require no training, and promote freedom of expression. However:

1. **Worksheets do not promote collaboration between students**
2. **Teachers do not have a definitive method for analyzing student responses and classroom trends**



The InterLACE Worksheet is a low cost solution which promotes collaboration, while minimally disrupting the classroom workflow (more intuitive)

User Workflow



Here is an example of an ideal student workflow using the InterLACE Worksheet.

Effect on Teacher Workflow

- ***Minimally disruptive***: teachers use a batch scanner to collect worksheets and get immediate feedback on their students' work
- ***Informative visualizations*** about how their class collaborates and identify actions that encourage collaboration
- ***Immediate analysis*** of students' works means teachers can make ***data-driven decisions*** to slow down or speed up the pace of their classes

Project Components

Image Processing → Information Processing → Data Visualization

Image Processing

Input: Raw image
Output: Data extracted from image

Why can't this be solved with OCR[c]?	*Text Localization*	*Text Recognition*	*Refined Text Recognition*
• Children's handwriting is highly variant[8] • Spelling mistakes are common • Scanned images contain noise	• Gaussian blur • Static and adaptive thresholding • Image contours • Sliding window • Throw out regions of interest perceived to be noise	• **Numbers**: Support Vector Machine using HOG[d] as features • **Words**: Convolutional Neural Network trained with synthetic images[6,7]	• **Many-to-One**: Find the word in a dictionary with the highest probability[e] of being the recognized word • **Many-to-Many**: For each word in a list of recognized words, find the word in a dictionary with the highest probability[e] of matching

Information Processing

Input: Data from images
Output: Data analysis tools

- **Node color** - student
- **Line color** - matches student giving help
- **Line thickness** - how often a student gives help
- **Node proximity** - frequency with which two students collaborate

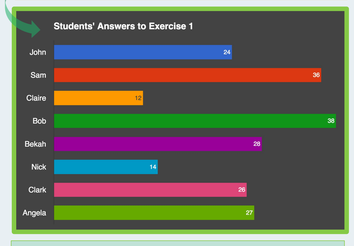
- **Bar color** - student
- **Bar length** - magnitude of student answer
- Allows students and teachers to quickly get a sense of the variety in a set of students' answers to a particular exercise

- **Dot color** - student
- A scatterplot collecting measurements taken by all students in the class displays trends in the data that would go unnoticed if students only looked at their individual data

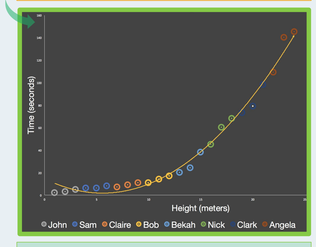
Data Visualization

Input: Tools for data analysis
Output: Visualization of data

Student Collaboration Graph



Student Comparison Bar Graph



Aggregate Class Data Scatterplot

InterLACE Benefits

Intuitive
- Scanning worksheet is only change made to students workflow
- Teachers do not have to change their teaching methods or worksheet questions

Iterative
- Students are encouraged to complete an assignment multiple times
- Promotes active questioning of self and peer ideas

Collaborative
- Students are encouraged to work within groups to solve problems
- Groups of students can easily view other groups ideas

Low Cost
- Scanners for each classroom are inexpensive
- No training required for interacting with UI

Flexible
- Teachers may continue to expand the worksheets
- Student "profiles" will grow overtime (days, months, years)

Future Work

- Allow students to create custom tags when writing on their worksheets so that the most often tags used by a class could be displayed to the students, student answers could be filtered by tags, etc...
- Learn to identify students over time by their handwriting, allowing multiple students to write on a worksheet and be automatically identified
- Display relevant information from the internet based on the content of their writing on a worksheet
- Enable students to write code on a physical worksheet that could then be executed in a web browser after the worksheet has been processed

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[4] DeWitt, P. (2013). Are schools prepared to let students BYOD? Education Week.
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[7] Jaderberg, Max et al. *Synthetic Data and Artificial Neural Networks for Natural Scene Text Recognition*. *CoRR* abs/1406.2227 (2014): n. pag.
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[a] Interactive Learning and Collaboration Environment
[b] iPads and Laptops
[c] Optical Character Recognition - Identification of printed characters using computer software
[d] Histogram of Gradients - Feature descriptor which counts occurrences of gradient orientations in localized portions of an image
[e] Based on Levenshtein Distance, a string metric for measuring differences between two sequences