AdapDif: A CASE STUDY ON AN ONLINE APPLICATION SUPPORTING

TEACHERS' DIFFERENTIATION EFFORTS

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A Capstone project

Presented to

The Faculty of the Curry School of Education

University of Virginia

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In Partial Fulfillment

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Doctor of Education

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by

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Curriculum and Instruction
Curry School of Education
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APPROVAL OF THE CAPSTONE PROJECT

This capstone project (" AdapDif: A Case Study in Developing an App for Differentiation") has been approved by the Graduate Faculty of the Curry School of Education in partial fulfillment of the requirements for the degree of Doctor of Education.

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Committee Member, Catherine M. Brighton, Ph.D

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Committee Member, Tonya R. Moon, Ph.D

_____Date

DEDICATION

I dedicate this Capstone Project to Jude and Bernadette, who are tiny and

forgiving and have dedicated 7/8ths and 7/10ths of their kid-lives to this project.

I also dedicate it to the memory of former iLab director and mentor, Kathryne

Carr (1955-2015), who forced me to get the ideas out of my head and into an MVP, no

matter how much I fought her on it. We truly would not have built a thing without her

financial support and obstinance.

ACKNOWLEDGEMENTS

I required enormous assistance over an extended period of time to convert an idea to a start-up to a research study and, finally, to this culminating Capstone Project.

Firstly, I would like to express my sincere gratitude to my advisor Dr. Carol Tomlinson for her bottomless well of patience, flexibility, insight, and eternal belief; to Dr. Tonya Moon for consistently going beyond her required professional duties to provide me with mentorship, opportunities to grow, and discipline that I often lacked; finally, to Dr. Catherine Brighton for her always being a "warm demander," helping me navigate academia and keeping my creative spirit alive.

I need to also gratefully acknowledge the leadership at the Batten Institute for Entrepreneurship's iLab for supporting us in the Incubator and continuing to offer us office space after our official tenure ended.

I need to thank my circle of co-workers who have become dear friends. You have continually gone above and beyond your collegial duties to watch my kids, help me not lose things, offer tons of feedback, and help me maintain my sanity.

Finally, I must acknowledge the friendship, dedication and partnership of Caner Uguz, my AdapDif other half.

You all are believers, and I am generally lost without you.

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EXECUTIVE SUMMARY

This study traces the experience of an educational technology start-up, AdapDif,

that developed and tested an online application addressing the following educational

problem of practice: Teachers are expected to differentiate instruction to improve

learning for the diversity of students in their classroom, yet they struggle to do so. As a

Capstone Project, the resultant implications, recommendation and actions are targeted to

AdapDif's specific context.

Two research questions drive the study: What can be learned in the development

process of an educational technology with a pedagogical mission? In what ways do

teachers engage with an online tool designed to support their attempts to differentiate

instruction? Two models frame the data: The New Concept Development (NCD) model

provided a lens for analyzing AdapDif's experience in converting theoretical solutions

into a concrete product; Tomlinson's Concept Map of Differentiation ground research in

the educational domain.

The study is framed as case study using archival data from the development

process (e.g., meeting notes, prototype wireframes, funding pitches and grant

applications) and from user testing (e.g., classroom observations, interviews, think-

alouds, and classroom artifacts). Findings are presented in two phases: AdapDif's

Development (Phase I) and Prototype-Testing (Phase II). Phase I is bounded by a

timeline that begins with the conception of an online technology (i.e., November, 2011)

and ends in the development of a minimum viable product (MVP). Phase II is bounded

by the beginning and ending (August 2014-May 2015) of user testing.

Phase I findings suggest that the processes recommended for start-up companies

can conflict with the processes of an early stage venture trying to develop an educational

product meant to solve a problem of practice. The rush to an MVP and the emphasis on

market analysis can lead to a fragmentation or oversimplification in the solution. Phase

II findings reveal that AdapDif's solution—an online application—did not help teachers

fully realize differentiation principles and practices; however, a more complex version of

the application could nudge them in that direction. Further, findings reveal that the

problem of practice may be distilled to teachers' perceptions of time as proxy for

complexity.

In this study I suggest the following implications:

- In seeking financial resources to develop a product that will go in schools,
  educational start-ups should weigh the risks and limitations of funding
  choices and their concomitant processes.

- A solution must 1) respond to the reality that teachers will have different
  point of entry into differentiation, and 2) explicitly teach about
  differentiation, from philosophy to practice, in order for teachers to take
  their different next steps.

- While there is merit in making solutions approachable and familiar to
  users, discrete, decontextualized tools cannot lead teachers to enact the
  big picture of differentiation. Solving the part, not only does not add
  enough value to the differentiation ecosystem.

- Teachers benefit from active support, both instructionally and with tech

  integration, that allows for reflection, collaboration and coaching.

- The solution must move beyond being a "neutral" platform that houses

  tools and training; it must interact with users in ways that nudge them

  toward new behaviors.

CHAPTER 1: STUDY DESCRIPTION

Introduction: Problem of Practice

Not since the early 1900s has the diversity in our schools been so pronounced (Kibria, Bowman & O'Leary, 2014). As student populations become more heterogeneous, classroom teachers face challenges stemming from complex demographics: Classrooms are comprised of "more students with learning issues— identified and unidentified—more students with emotional challenges, more students whose first language is not the language of the classroom, more students from stressed homes, and students from a broader spectrum of economic strata" (Tomlinson, 2013, para 1). For example, federal polices of inclusion have increased students with special needs in mainstream classrooms (Aud et al., 2012). Also, children of immigrants now account for one-fifth of all students in pre-kindergarten through 12th grade classrooms (Fortuny, & Chaudry 2010), and the percentage of students identified as English Language Learners continues to increase (Kena et al., 2016). These demographics become important when considered in the context of the achievement gaps that still remain between African-American and Hispanic students and their Caucasian and Asian counterparts (Paschall, Gershoff, & Kuhfeld, 2018; Hemphill & Vanneman, 2011). Not only have classrooms become increasingly varied in terms of language, ethnicity, and special needs, but, as always, students without the learning impediments still vary wildly in readiness, interests, and preferences towards learning.

External pressures exacerbate already complex classroom dynamics. "Rigorous content" is a key expectation of the Common Core Standards (Council of Chief State School Officers & National Governors Association, 2010), and, in accordance with 21st century expectations, teachers also are being asked to elevate their students from consumers of knowledge to generators of new information (Center for Public Education, 2009). Furthermore, thanks to the seismic shift from minimum-competency testing to tests with "high-stake" consequences (Moon, Brighton, Jarvis & Hall, 2007), teachers are now pressured "to raise the standardized test scores of students who clearly are not standardized" (Tomlinson, 2004, p. 28). Finally, teachers are also feeling pressure from toughened teacher evaluation systems which demand that all students succeed by showing growth on standardized measures (Popham & DeSander, 2014). The pedagogical conclusion from these facts is unsurprising: "Schools obviously will need to develop the capacity to teach a more diverse population of students" while concurrently preparing "those students to deal with diversity" (Center for Public Education, 2009, p. 17).

Differentiation as Pedagogical Response to Diversity

Tomlinson (2003) suggests Americans equally cherish the sometimes-competing values of equity and excellence, a struggle that manifests in our schools. These "twin values" can be addressed in our classrooms:

> A curriculum furthers excellence when it opens doors to a promising tomorrow. Instruction furthers excellence when it moves a learner as effectively as possible toward expertise as a thinker, problem solver, and producer. And procedures, policies, and practices further equity when they maximize the likelihood that each learner will be a full participant in an excellence-based education (p. 10).

Differentiation is an approach to teaching and learning, both philosophical and practical, that embraces these dual goals. While the model has evolved over time, differentiation has always been rooted in an unwavering set of ethical assertions: (a) "Human differences are not only normal, but desirable," (b) "a growth mindset is fundamental to teaching that enables equity of access to excellent learning" (Tomlinson, 2015, p. 203), and (c) teachers must be "engineers[s] of student success" and "champions of every student who enters the schoolhouse doors (Tomlinson, 2014, p. 36).

Differentiation has become a ubiquitous pedagogical response to students who arrive at school prepared unevenly for prescribed academic standards, motivated by a variety of interests, and compelled by various approaches to learning (Tomlinson, 2014). Without a belief system that aligns with the philosophy of differentiation and an understanding of the principles and practices that support it, educators risk either (a) reducing differentiation to a prescribed set of instructional strategies and, as a result, implementing it superficially, or (b) developing misconceptions and rejecting it entirely. Almost 20 years after the original publication of *The Differentiated Classroom* (Tomlinson, 1999; 2014), it remains to be seen whether teachers do, in fact, have this comprehensive understanding that differentiation is a complex system of interdependent principles and practices. While the term has saturated the educational landscape— ubiquitous in textbook guides, professional development catalogues, and marketing materials for educational technology—the implementation of differentiated instruction is often superficial, if present at all, and teachers express misgivings about being able to do

it well (Mills et al., 2014; Tomlinson et al., 2003; Roiha, 2014). Still, the challenge of

classroom diversity remains, and the demand to reach all students intensifies.

Statement of Problem

Whether compelled by conscience or external edict, teachers are aware of the

need to differentiate instruction, and while differentiation has been part of the educational

fabric over the past 20 years (Aliakbari & Khales Haghighi, 2014; Callahan, Moon, Oh,

Azano, & Hailey, 2015; Little, McCoach, & Reis, 2014; Sherman, 2009; Sousa &

Tomlinson, 2011; Tomlinson, 2001), a number of studies examining teacher attitudes and

practices have found that teachers do not differentiate in a robust way, if at all (Callahan,

Tomlinson, Moon, Brighton, & Hertberg, 2003; Johnsen, Haensly, Ryser, & Ford, 2002;

Santangelo & Tomlinson, 2012; Tobin & Tippett, 2014). According to Tomlinson (2013),

despite the increasing variety of students in our classrooms, there is "abundant evidence

that we do not serve students well, and we still teach as though all students of a given age

are essentially alike" (para 1). The fact that teachers struggle with differentiation is only

the first layer of the problem of practice; understanding *why* they struggle is perhaps less

clear.

Practitioners and researchers attribute the resistance to implementing

differentiation to different sources. Teachers, for example, tend to list a common set of

logistical challenges that Tomlinson and Imbeau (2010) refer to as "yes–buts" (e.g., "I

can't differentiate instruction because I teach too many students"; "I can't differentiate

instruction because I'm already too busy and have absolutely no extra time for planning")

(p. 137). Because of these perceived logistical impediments, practitioners tend to seek

simple solutions with little infringement on their time. Sherman (2009) explains,

"Though they are committed and well-intentioned, overwhelmed and overworked

teachers may go directly to recipes for implementation rather than carefully regarding

how theory can guide them to imaginatively meet diverse students' needs in situationally

specific contexts" (p. 57). Researchers (e.g., Brighton, 2003; Mills et al., 2014;

Tomlinson et al., 2003) suggest that superficial implementation of differentiation is

related to teachers not fully understanding its complexities and nuances. Simply

providing teachers with tools or techniques—in the absence of training—results in either

misuse of these tools, or the reduction of the teacher to "a mere technician with a sterile

bag of tricks" (Silberman, 1973, p. xxi). Sherman (2009) supports this contention and

stresses the importance of teachers understanding the educational principles that

undergird the strategies and structures of differentiation, claiming, "Techniques alone

cannot sustain progressive educational environments" (p. 45).

The problem of practice for this Capstone Project—teachers struggle with

differentiation—can be nuanced in a series of questions: How do we practically reconcile

teachers' desire for practical support (e.g., models, tools, examples, cut-and-paste

templates) with what research suggests: teachers would benefit from deeper knowledge,

be it content or pedagogical content knowledge (Ball, Thames & Phelps, 2008; Hill,

Rowan & Ball, 2005; Shulman, 1986)? Is there a solution that is both expedient (i.e., to

appeal to teachers) and edifying (i.e., to reflect research findings and expert insight)? Is a

solution even located in this tension between tools and training, or is it something else

completely?

Capstone Context and Purpose

Two doctoral students from the University of Virginia's Curry School of

Education, Mindy Moran (i.e., the author of this capstone) and Caner Uguz, partnered to

explore answers to those questions. Shared interests in curriculum, instruction, and

technology provided a common language, while our individual areas of expertise in

differentiation and instructional technology, respectively, impacted our search for

answers. Furthermore, we both believed that the affordances of online technologies—

omnipresent and with almost limitless potential—could be leveraged to make

differentiation more accessible to teachers. We understood "differentiation [to be]

heuristic, or principle-driven, rather than algorithmic, or formula-driven," and so

meaningful solutions are not easily programmed (Tomlinson, 2014, p. 25). We wanted to

map an intersection between differentiation and technology, and this Capstone Project

analyzes that three-year process. Our relationship began as like-minded colleagues

engaging in informal, academic bantering, and culminated in the creation of an online

application used by classroom teachers. The following sections establish the context for

this project by explicating 1) our backstory, 2) the "connected differentiation model" we

created to frame our solution, 3) our development plan to build it, and 4) the purpose of

this study.

Backstory
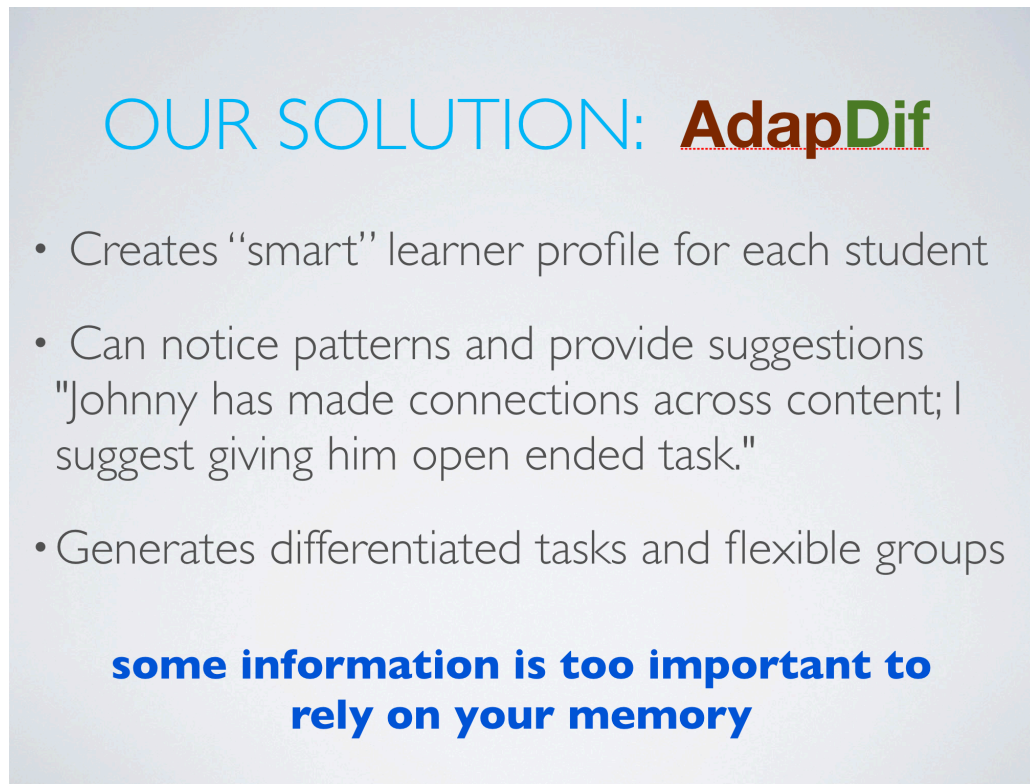
Compelled by a potential $3,000 prize in the Curry Cup 2012 Entrepreneurial

Concept Competition, we began fleshing out ideas about the theoretical convergence of

differentiated instruction and adaptive learning technology (i.e., dynamic learning

experiences customized by user input and interaction). In our concept proposal for that

competition, we argued,

> Lack of time for planning and instruction is the number one obstacle that teachers
> profess towards continued success. Tools for teaching, therefore, should
> maximize the efficiency of teachers that would allow them to concentrate on
> instruction. We suggest that a major portion of work that would go into
> differentiation in the classroom can be done with the smart use of digital tools
> that help teachers collect and analyze data to produce classroom ready
> components (Concept Proposal, 11/2/13).

We refined that general contention for the competition presentation, claiming that

teachers needed adaptive learning tools to (a) capture instantaneous, relevant, and often

"informal" data and, more importantly, (b) quickly make sense of that information and

translate it to meaningful tasks that meet students at their level of readiness. We outlined

our theoretical solution (Figure 1) as a technology that would create "smart" learner

profiles, recognize patterns in student data and offer insights, and generate instructional

suggestions. Our tag line, "some information is too important to rely on your memory,"

suggested that the technology could lighten a teacher's cognitive load (Paas, Renkl, &

Sweller, 2003)—the "burden" of knowing so many students—and free teachers to focus

on meaningful instruction. We won that competition, and the judges advanced the team

to the university-wide competition with the caveat that the venture capitalist judge would

provide advise on the business plan segment of the presentation.

While we did not win the competition, a representative from the iLab (i.e., a co-

venture between the Batten Institute for Entrepreneurship and Innovation and the Darden

School of Business) invited us to their start-up Incubator. As a condition of our

participation, in April of 2013, we formed a Limited Liability Company (LLC),

Figure 1. AdapDif's theoretical "solution" for teachers struggling with differentiation. Keynote slide from Curry Cup Competition Presentation, 11/12.

"AdapDif." Generated hastily upon realizing the competitors at the Curry Cup had

named their ventures, AdapDif (i.e., a mash-up of adaptive learning and differentiation)

became a synonym for the company, the concept, and the product we eventually created.

We received an $8,000 grant that was allocated for company development to be

distributed in two installments. The iLab released the second portion of money only after

AdapDif spent funds responsibly and according to approved iLab's regulations. They

also provided office space and business mentorship for a 12-month period. The bulk of

development discussed in this Capstone occurred during first three months, an intensive,

summer "accelerator" during which we were not permitted to have other employment.

Connected Differentiation Model

While in the Accelerator, AdapDif transformed our proposed "solution" into a

physical product. As we tinkered with ideas, we recognized that our competition

proposals had suggested capitalizing on the affordances of technology to satiate the

teacher-desire for tools and strategies; however, we had not addressed the academic

contention that teachers' struggle with differentiation stems from a lack of understanding

its complexities. A layer of professional learning seemed necessary. We synthesized

these ideas in a Connected Differentiation Model (see Figure 2), a theoretical model that

connected pedagogy to practice. We operationalized that model as technological solution

called *The AdapDif System*. We proposed that this system would eventually incorporate
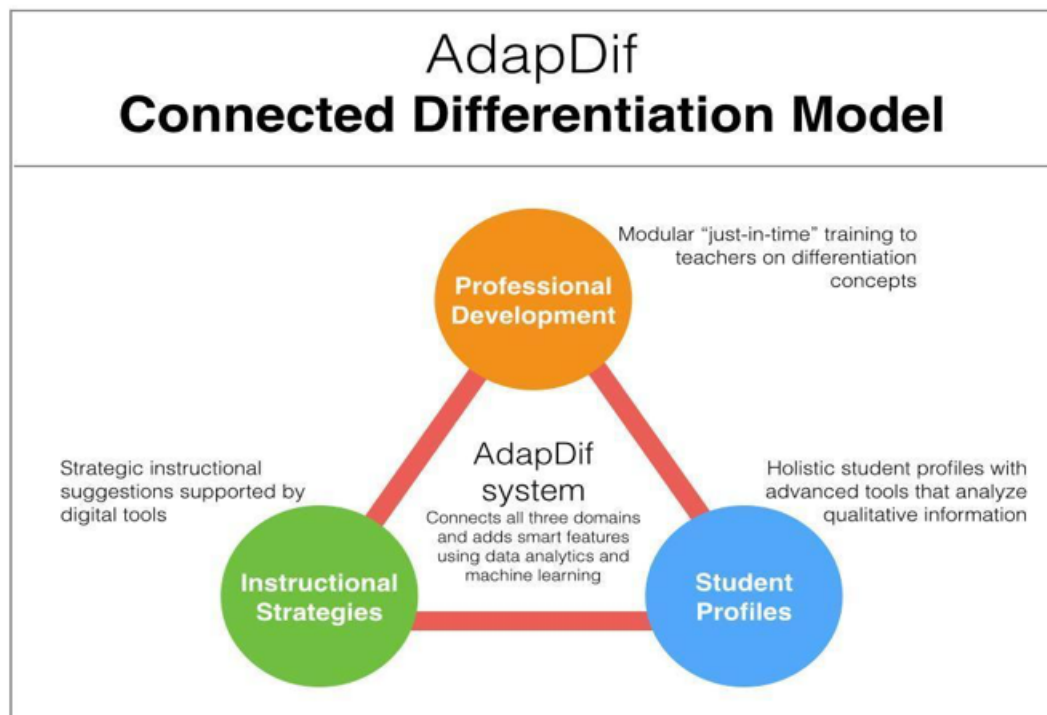
Figure 2. Connected Differentiation Model on which the theorized AdapDif
System would be built.

data analytics and machine learning to make suggestions to teachers through (a) evolving,

holistic student profiles, (b) instructional strategies that adapt to student needs, and (c)

targeted professional development in the principles and practices of differentiation.

Evolving, holistic student profiles. These student profiles would consist of data

about the student, gathered in the classroom rather than imported from the district. These

data could include student interests, learning preferences, and/or readiness for a learning

objective. This functionality would compile comprehensive profiles from which teachers

could base instructional decisions. The system could potentially capitalize on natural

language processing to analyze the qualitative data in the profiles.

Instructional strategies and tools. Differentiation strategies (e.g., jigsaw, RAFT,

tiered tasks), arduous to execute with paper and pencil, would be made easier as a toolkit

of digital tools or applets (i.e., a small programs that run inside a larger application).

These tools could eventually support teachers by making instructional recommendations

(e.g., suggesting optimal grouping based on patterns in data collected about the students).

Professional development. Meaningful differentiated instruction requires a level

of expertise that cannot be developed in a one-day workshop; effective training inherently

requires a commitment made over time and with multiple opportunities for application

(Tomlinson, 2005; Wayne, Yoon, Zhu, Cronen & Garet, 2008). Traditional professional

development formats encourage neither deep understanding nor opportunity for

immediate application to classrooms (Darling-Hammond, Wei, Andree, Richardson, &

Orphanos, 2009; Tomlinson, 2005). We planned for *just-in-time* training (Greenhalgh &

Koehler, 2017) to occur contextually as teachers interacted with the application and its

content based on those interactions. This learning would take the form of modular,

video-based training segments that would help teachers better understand the principles

and practices of differentiation as they encountered them in the application.

Development Plan

To translate this theoretical system into a reality, we devised a three-stage

development plan and executed it to the extent that resources (e.g, funding and time)

allowed. We completed Stage I, which encompassed our time in the Incubator and

culminated in a functioning online application. Stages II and III remain hypothetical.

Development Stage I. Development began with student profiles, a logical

starting point based on a fundamental premise of differentiation: In order to reach

students, teachers must first get to know them—their interests, learning preferences, and

readiness for the content they need to learn. After systematically gathering information

from and about their students, teachers can look for patterns in their classrooms on which

instructional decisions might be made. With those patterns in mind, they can then design

instruction that is targeted, meaningful, and engaging.   This instructional "line of

logic" (see Figure 3) suggests differentiation involves constant, iterative movement

between planning high-quality curriculum (e.g., "PLAN"), assessing where students are

relative to that curriculum (e.g., "ASK"), and making instructional decisions based on

what teachers know about their students (e.g., "TEACH"). We focused on the ASK step

in building out the application.

The App. The AdapDif team created an online application designed to integrate

into a teacher's existing workflow. Appealing to teachers' propensity for tools and taking
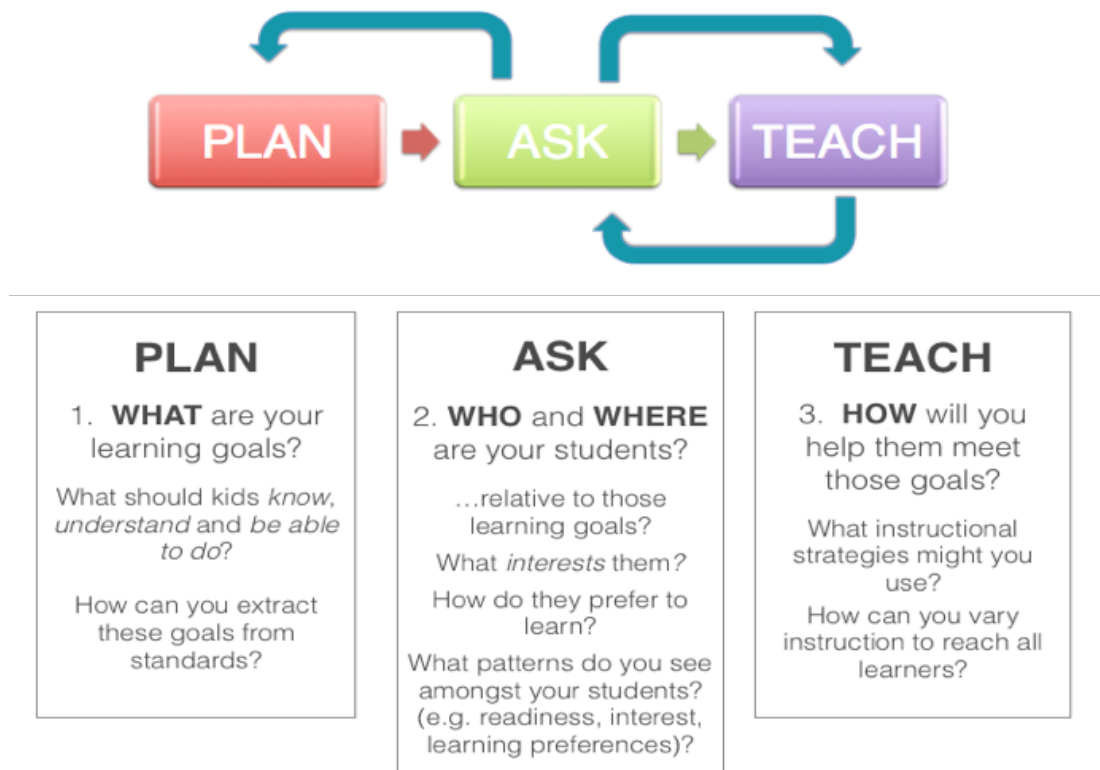
Figure 3. AdapDif's Instructional Line of Logic—Plan, Ask, Teach. From AdapDif
User Guide.
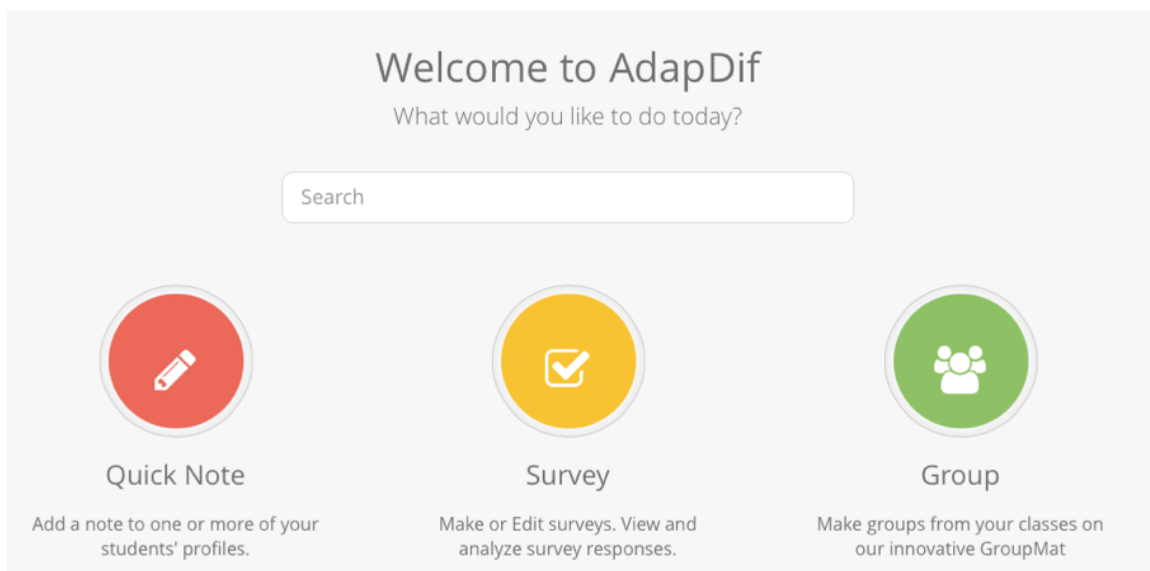
Figure 4. The app's homepage, showing the three tools in the application: Quick Note,
Survey, and Group. Screenshot of the app.

a "meeting them where they are" approach, AdapDif built an online application (see

AdapDif homepage in Figure 4) comprised of a set of practical tools or features—Quick

Note, Student Profile, Survey, and Group.

Quick Note. This tool allows users to record observations and insights about

students (Figure 5). When a teacher types a student's name into the note (i.e., "Type your

note here") the application automatically recognizes the name (i.e., "Students in this

Note") and attaches the observation data to the corresponding Student Profile.

Student Profile. This feature collects all data entered by or about the student in a

profile page (Figure 6). Data include Quick Notes taken by the teacher and student

responses to survey questions.

Survey. This tool allows teachers to create survey or assessment questions for

students (Figure 7). Survey questions can be used to pre-assess where students are

relative to the learning goals or serve as quick checks that capture students' understanding

as a lesson is progressing. Teachers can also uncover student interests or learning

preferences. Teachers can then view the survey results of the whole class to help them
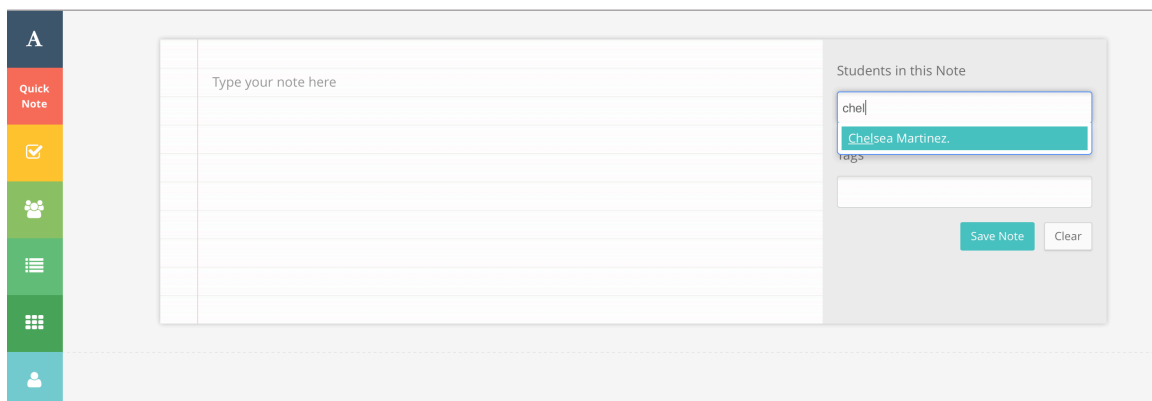
Figure 5. Example of Quick Note function: Teacher types a note and assigns a
student to the note. Screenshot of fake student data created for presentations.
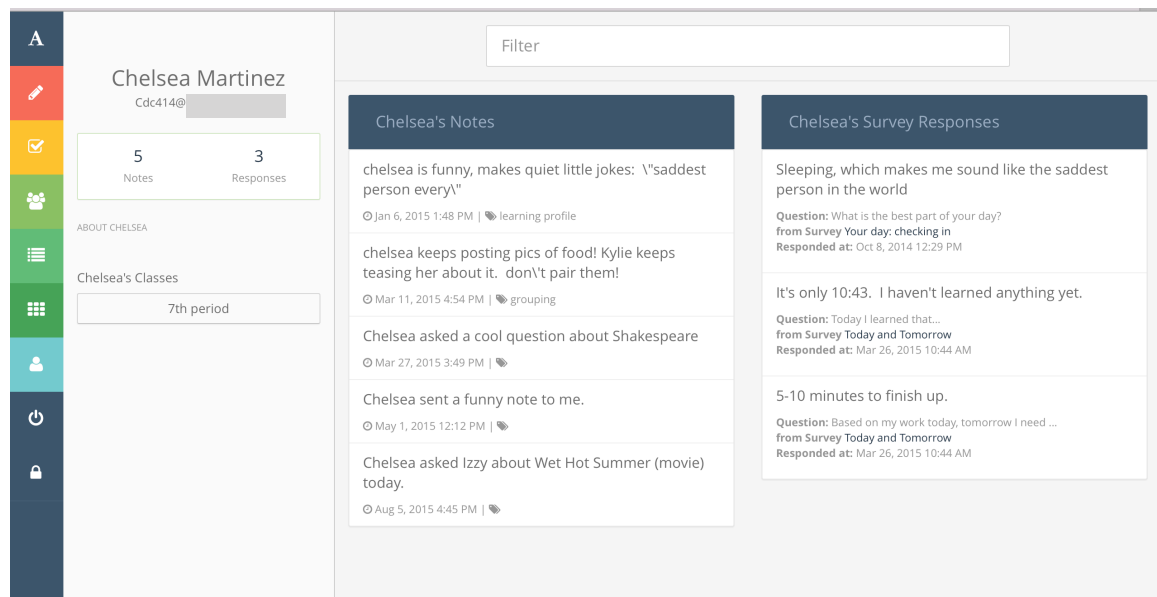
Figure 6. Example of Student Profile (corresponding to Figure 5). *Screenshot of fake student data created for presentations.*
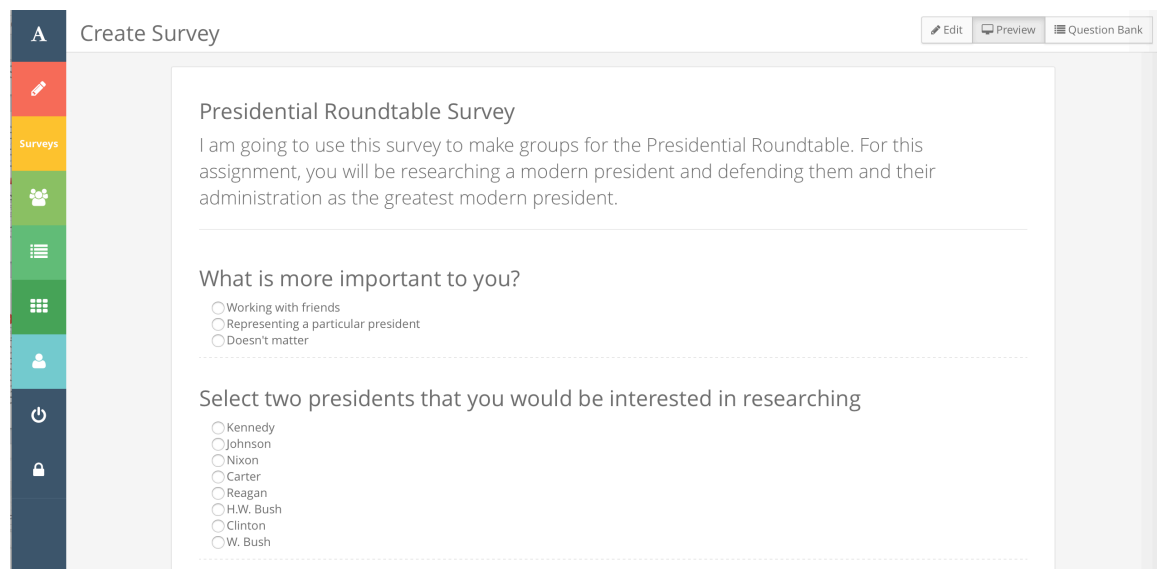
Figure 7. Teachers can create surveys that are emailed to their students. This example comes from Mr. Grayson, participant in this study. Screenshot of Survey preview from

find commonalities among students (See Figure 8). Multiple choice questions in this tool

are connected to the Group tool.
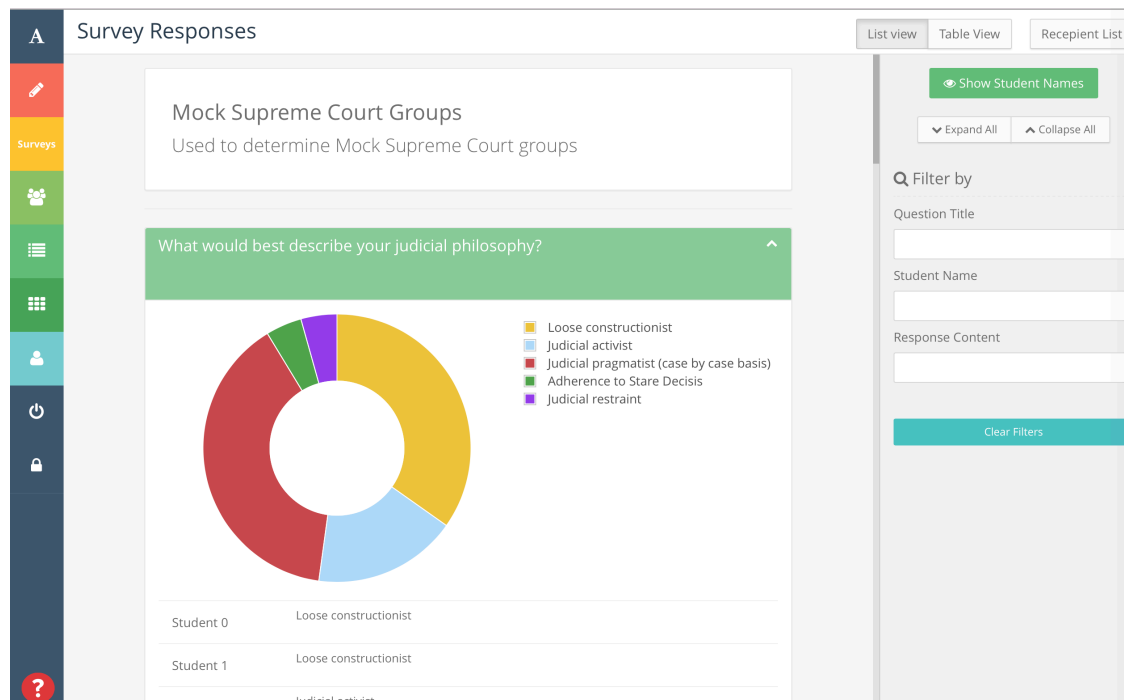
Figure 8. Survey tool displays student responses to teacher. Screenshot from app
with student data made anonymous.

Group. This tool, also referred to as "GroupMat," provides a work area for

teachers to analyze survey data and then group students based on responses (Figure 9).

Teachers can analyze students' survey responses to determine small groups and/or next

steps in instruction.

Development Stage II. The Connected Differentiation Model integrates

professional development with the aforementioned tools. Without this support, we

hypothesized that teachers may not maximize them, particularly to modify instruction.

Based on this assumption and the belief that teachers need to better understand

differentiation, we speculated that Stage II development should embed a "professional

learning layer" throughout the application to help teachers better understand the

principles and practices of differentiation while they use the tools in the context of their
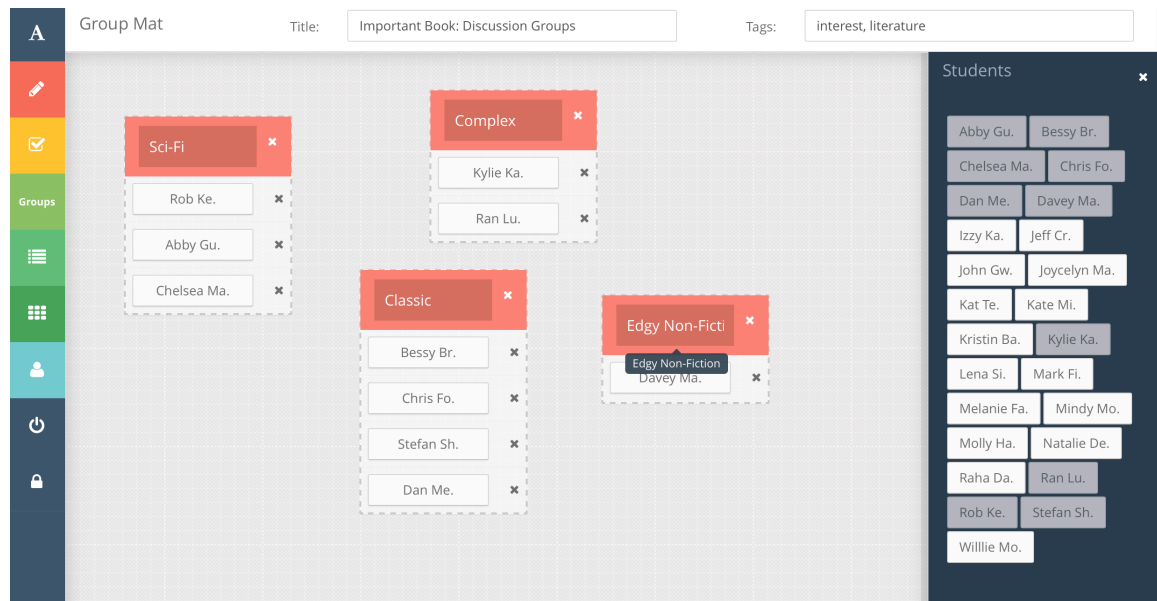
Figure 9. The GroupMat provides a space for teachers to group students. Screenshot of app with fake student data created for presentations.

planning and instruction. While the team began to generate ideas about what these might entail, this development stage was not integrated into the application.

Development Stage III. Ultimately, AdapDif's vision would manifest in an online system whose underlying adaptive technology could make instructional suggestions, raise relevant questions, and display patterns to users. Figure 10 illustrates what these suggestions might look like. This final, ambitious development phase could occur only if and when AdapDif has grown a large enough user base and is staffed with statisticians, experts in natural language processing, and a team of programmers. Ideally, the recommendations could flow freely through the system, and as the system gets "smarter," differentiation becomes more sophisticated. The software could learn and aggregate the individual behavior of teachers and students and begin to learn patterns among classrooms that could become aggregate learning to be shared across the network.
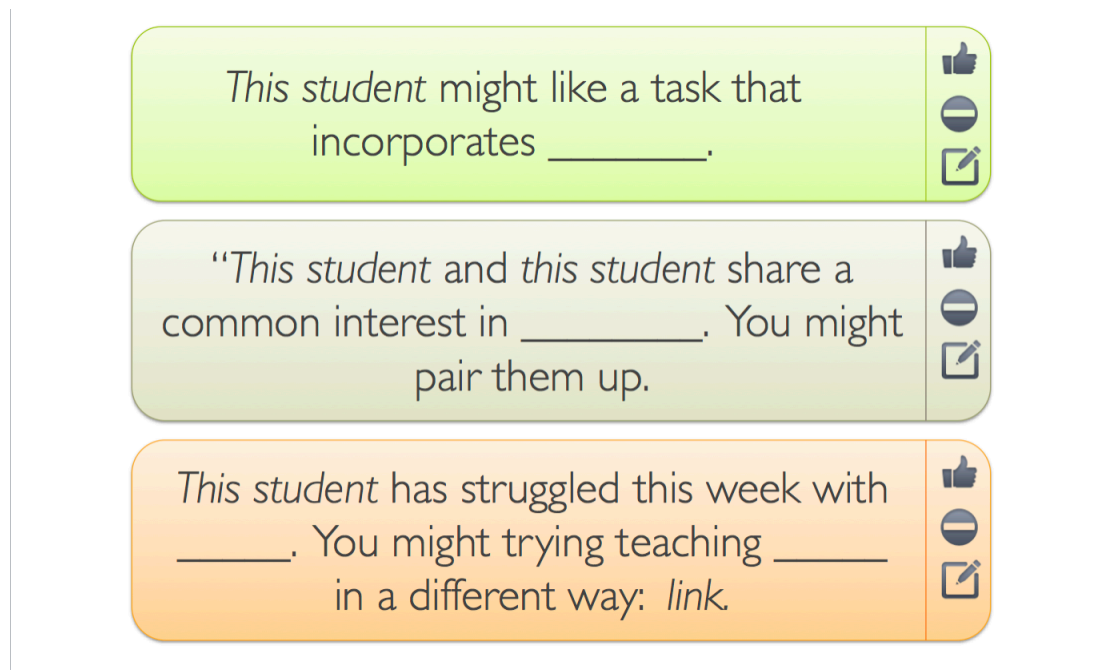
Figure 10. Mock-up of how the AdapDif system might make suggestions in future iterations using adaptive learning. Slide from E-Cup presentation, 12/12.

Stages II and III have been tentatively outlined, but the recommendations from this capstone will inform those next steps in development, and, in fact, may alter them significantly.

Capstone Purpose

AdapDif's journey from concept to product has been driven by educational theory and research but also influenced by the entrepreneurial focus of the Incubator. While the progression was by no means arbitrary, it was fast-moving, organic, and, frankly, unexamined. This Capstone Project provided an opportunity to systematically analyze AdapDif's three-year process of developing a fully-functioning online application. In a larger sense, this study sheds light on the complex process of creating a research-based, educational application impacted by the business imperatives of a start-

up Incubator. Because the application was tested with classroom teachers over a school

year, this analysis provides some insight into the successes and failures of teachers

attempting to differentiate their classrooms using this technology. More concretely, the

overarching goal of this Capstone Project is to provide recommendations to inform

AdapDif 's next steps—to decide if the development stages as outlined are plausible and

to understand if the AdapDif system begins to answer the questions raised by the problem

of practice.

Definition of Terms

To avoid repetitious language, some terms are used interchangeably throughout

this text. The following list explains those terms, as well as clarifying others:

- *AdapDif/the AdapDif team/"we"*: Refers to the company, Caner Uguz and me,
  unless specified otherwise (i.e., an intern or programmer included in a meeting).
  Because of membership on the AdapDif team and my role as researcher, the use
  of first person (i.e., "I asked the teacher…") occurs more frequently than would
  be typical in an academic paper. The studious avoidance of first person would
  be a contrivance that would inhibit its readability.

- *The technology/the app/the application/the system*: AdapDif created a
  web application—a computer program that runs on a remote sever (as opposed
  to being downloaded to the user's computer) and is accessed through a web
  browser. While strictly speaking, *technology* can broadly be defined as tools
  created to solve problems, this Capstone Project refers to "digital tools" (e.g.,

interactive whiteboards, mobile devices, online applications) as opposed to

"analog" tools (e.g., paper/pencil, sticky notes, manilla folders).

- *MVP/prototype/the product:* These terms are used in reference to the application

  in its first iteration, the version that was tested with teachers. In product

  development, an MVP is a Minimum Viable Product, a version of the product

  containing enough features to test with an audience while limiting the risk of

  costly production if assumptions are incorrect. This term is a key part of the

  lean start-up methodology.

- *Alpha/beta:* In software development, an alpha version of a product is usually

  an early version tested in-house, while beta-testing is a second phase in which a

  small segment of the intended customer base uses and critiques it. We used the

  terms interchangeably throughout the process (e.g., The login page of the app

  reads, "AdapDif is currently in private beta," but once logged in, the bottom of

  the app reads, "AdapDif is currently in alpha stage testing.").

- *Backend:* Although more technical definitions exist, in this paper, the backend

  refers to the part of the application that houses databases and is not accessible

  by the user. In the case of AdapDif, the backend was only accessed by the

  programmer.

- *Bug:* A software bug is an error, flaw, failure, or fault in a computer program or

  system that causes it to produce an incorrect or unexpected result, or to behave

  in unintended ways.

- *Onboarding:* This refers to the process of entering a user into a software system, and in AdapDif's case, creating teacher accounts.

- *Wireframe:* This development planning tool is a two-dimensional illustration of a webpage's interface that specifically focuses on space allocation and prioritization of content, functionalities available, and intended behaviors (https://www.usability.gov/how-to-and-tools/methods/wireframing.html).

- *Just-in-time:* Used in reference to professional development in this Capstone Project, this is an intervention designed to provide the right type/amount of support, at the right time; it becomes adaptive when it responds to an individual's changing internal and contextual state (Nahum-Shani et al, 2016).

- *Accelerator/Incubator:* The meanings of these terms shift and evolve, but they refer to a short-term, cohort-based program that supports start-up enterprises through mentorships. Typically incubators provide office space and sometimes funding in exchange for a small amount of equity in the company. In this capstone, the iLab Incubator program ran for one year, provided office space, $8,000 in funding without taking equity, and mentorship. The Accelerator refers to the period between the end of May through the middle of August, 2014.

- *Pitch/Pitch Deck*: A pitch is a persuasive description of a company/start-up (or the idea for a start-up) intended to excite investors; a pitch deck is a brief presentation with the same goal.

- *Groups/Grouping Event*: Groups refer to students who have been sorted, using the GroupMat tool when indicated.

- *AVID*: Advancement Via Individual Determination is a program designed to help underachieving students with high academic potential prepare for entrance to colleges and universities (https://www2.ed.gov/pubs/ToolsforSchools/avid.html).

- *Learning Management System*: An LMS is a software application that allows users (e.g., school districts) to create, track, manage, and distribute (i.e., management) materials, educational courses, or training (i.e., learning), on a collaborative platform. Blackboard is an example of an LMS used by the district in this study.

- *Advanced/Standard/Collaborative:* These represent the tracked or leveled classes in the school division where AdapDif tested the app. *Collaborative* indicates a special education instructor who co-teaches the course.

- *SOL*: Standards of Learning describe the expectations for student learning and achievement in grades K-12 in Virginia.

- *IEP:* Individualized Education Program is a document that outlines modification for a student receiving special education services.

Conceptual Frameworks

Conceptual frameworks provide a "map of the territory being investigated" that guide the identification of important variables and prediction of meaningful relationships in the data (Miles et al, 2014, p. 20). Two distinct frameworks guided this study. The

first, the New Concept Development (NCD) model, originates in the business world and

the literature on product development; as such, it provided a lens for analyzing AdapDif's

experience converting theoretical solutions into a concrete product. A second model was

needed to equally ground the study in the field of education. Tomlinson's Concept Map

(2014) illustrates the relationships between the principles and practices of differentiation

and provides a lens on the data generated as teachers used the application in their

classrooms.

Conceptual Framework #1: New Concept Development Model

We did not develop our solution to the problem of practice following a prescribed

process, and so, in selecting a framework to study AdapDif's journey from problem of

practice to solution, I considered the influence of the iLab, where our most intensive

work occurred. However, if the iLab directors based the Incubator programming on a

specific model, they did not make it explicit. While they seemed to have a dual-emphasis

on innovation (hence being housed in and named as an "innovation laboratory") and

entrepreneurship, the application to the program stated their mission was, "to support the

development and growth of promising seed- and early-stage business ventures" and listed

the following objectives:

- Fostering the formation and development of start-up businesses to break even

  cash flow or significant, third-party investment support;

- Educating participants about the process of new-venture development in

  order to improve their potential for future entrepreneurial success; and

- Creating an entrepreneurial community to give participants the experience of

  learning through mutual support, a process critical for successful

  entrepreneurship.

Because of that entrepreneurial emphasis, I also considered theoretical models.

Effectuation (Read & Sarasvathy, 2005), for example, was a possibility—born of seminal

study from a Darden scholar (Sarasvathy, 2001) who studied the way expert

entrepreneurs think and created a set of principles about what makes entrepreneurs

entrepreneurial. It is concurrently considered to be a theoretical model, a type of

reasoning, and a "logic of entrepreneurial expertise" (http://www.effectuation.org).

Despite eminence of effectuation at the Batten School (i.e., the UVA entity that funds and

sets priorities for the iLab) and its strong research base (e.g., Deligianni, Voudouris,

Lioukas, 2017; Dew, Ramesh, Read, Sarasvathy, & Virginia, 2018), the Incubator did not

explicitly teach its principles. More importantly, perhaps, the AdapDif team viewed

ourselves as educators, not entrepreneurs, and an effectuation lens would have

foregrounded the team instead of our processes and product. *The Lean Start-Up* (Blank,

2013; Ries, 2011) was another viable model, as "lean" ideas seemed to permeate

discussions in and around the iLab. Lean methodology suggests, after recognizing a

problem, a team should quickly build a minimum viable product (MVP) to test with

customers and engage in a build/feedback loop, ultimately trying to determine what

customers will pay for and if one should pivot or persevere. Despite the familiarly of the

terms (some of which will surface again in this paper), the lean start-up process has no

discernible research base to support a credible academic inquiry. In the end, the NCD

model provided the most compatible lens for focusing on the development of AdapDif's

ideas, not AdapDif's team. Furthermore, it is supported by a body of research (e.g., Kahn

et al, 2012; Koen et al, 2014) and emerged from long-standing models that have evolved

over time. The evolution of those models, New Product Development (NPD) and Fuzzy

Front End (FFE), into the NCD model is described below.

New Product Development (NPD). NPD (Cooper 1988, 2008, 2014) has been

the dominant model of the product innovation process since the late 1980s (recently

trademarked by its creator as the Stage-Gate Next Generations Idea-to-Launch System;

see Figure 11). This framework was "developed to deal with the random and

disorganized, often chaotic, approach to new-product development, once prevalent in

many major firms (and which is still a challenge for too many small and medium-sized

companies)" (Vedsmand, Kielgast, & Cooper, 2016, para 1). The latest iteration depicts

product development as a "gated" process that proceeds in a series of stages, punctuated
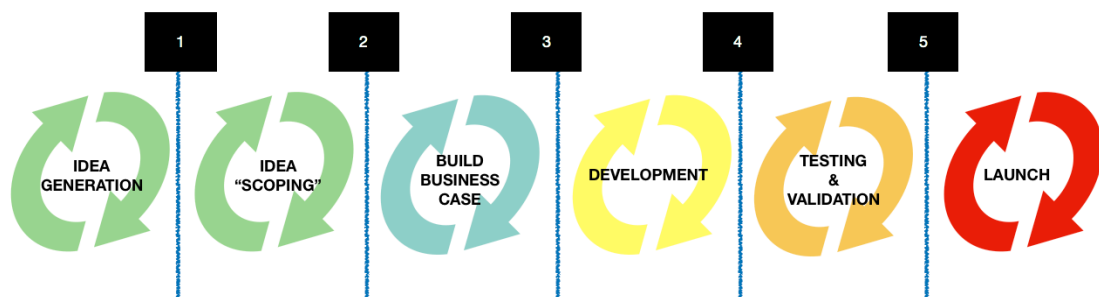
Figure 11. The Stage-Gate Next Generations Idea-to-Launch System: Stages begin
after idea generation, demarcated by five "gates." Adapted from "What's Next?:
After Stage-Gate," by R.G. Cooper, 2014, *Research-Technology Management,*
57(1), p. 21.

by "go/kill" decision points (Figure 11). While this roadmap has been widely adopted for

the structure it gives to the process of launching new products, it has had to evolve over

time as technology has enabled faster production cycles, and more emphasis has been

placed on discovery and ideation.

Fuzzy Front End (FFE). Researchers (e.g., Khurana & Rosenthal, 1998;

Markham, 2013; Reid & Brentani, 2004) have recognized both the value and necessity of

focusing more intently on the front end of the product development process, the idea

generation that precedes NPD (see Figure 12). This stage has been deemed fuzzy (Smith

& Reinertsen, 1991) because it is characterized by activities that are "often chaotic,

unpredictable, and unstructured" versus NPD, which assumes "formalism with a

prescribed set of activities and questions to be answered" (Koen, et al., 2004, p.30).

Although Koen and his co-authors (2004) agree that the FFE and NPD operate on a

continuum, they make clear distinctions between the two processes, such as the nature of

the work, how they are funded, activities involved, and the measures of progress (see

Figure 13).
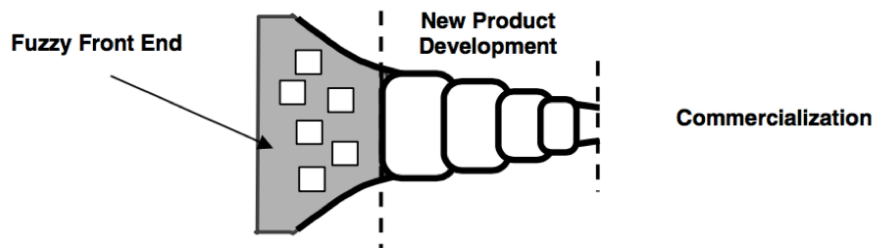
Figure 12. The innovation process, divided into fuzzy front end (FFE), new product
development (NPD), and commercialization, from *Fuzzy Front End: Effective
Methods, Tools, and Techniques* (p. 6) P. A. Koen et al., 2002, New York: Wiley

	Fuzzy Front End (FFE)	New Product Development (NPD)
Nature of Work	Experimental, often chaotic. "Eureka" moments. Can schedule work—but not invention.	Disciplined and goal-oriented with a project plan.
Commercialization Date	Unpredictable or uncertain.	High degree of certainty.
Funding	Variable—in the beginning phases many projects may be "bootlegged," while others will need funding to proceed.	Budgeted.
Revenue Expectations	Often uncertain, with a great deal of speculation.	Predictable, with increasing certainty, analysis, and documentation as the product release date gets closer.
Activity	Individuals and team conducting research to minimize risk and optimize potential.	Multifunction product and/or process development team.
Measures of Progress	Strengthened concepts.	Milestone achievement.

Figure 13. The difference between FFE and NPD. Reprinted with permission from *Fuzzy front end: effective methods, tools, and techniques* (p. 6) P. A. Koen et al., 2002, New York: Wiley.

AdapDif spent all our development time in the FFE; this is validated by our alignment to the characteristics of the FFE listed in Figure 13: The nature of the work was chaotic. Commercialization was uncertain, funding variable, and revenue expectations speculative. We conducted our own research and, maybe most importantly, we measured progress, not through milestones, but through strengthened concepts.

New Concept Development Model. To account for the complex, iterative nature of the FFE, researchers (2004) produced the *New Concept Development Mode*l, or *NCD* (Figure 14). This circular model suggests that ideas flow, circulate, and iterate between and among five elements of an inner circle:

- opportunity identification—the organization identifies opportunities that it

    might want to pursue, typically driven by business goals (p. 15);

- opportunity analysis—an opportunity is evaluated to decide if it is worth

    pursing (p. 17);

- idea generation and enrichment—birth, development, and maturation of a

    concrete idea, going through many iterations and including direct contact

    with customers (p. 19);

- idea selection—"selecting which ideas to pursue in order to achieve the most

    business value" (p. 22); and
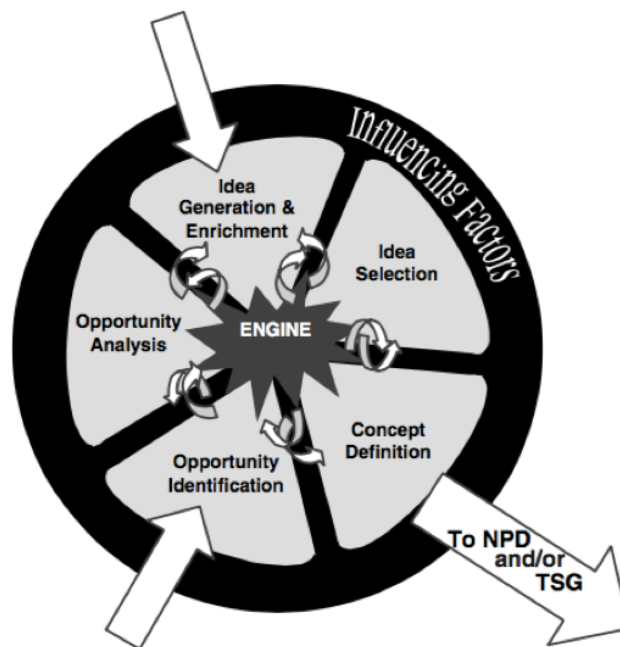
Figure 14. The *New Concept Development Model* represents the elements and
iterative nature of the FFE. Reprinted from Fuzzy front end: effective methods,
tools, and techniques (p. 8) P. A. Koen et al., 2002, New York: Wiley.

- concept definition—the exit to the NPD stage in which "the innovator must

    make a compelling case for investment in the business or technology

    proposition," typically culminating in a business plan or product proposal (p.

    26).

The outer circle represents influencing factors, which include the company's

organizational capabilities, customer and competitor influences, the outside world's

influences, and the depth and strength of enabling sciences and technology. This model,

specifically the elements of the inner circle, provided a frame to analyze AdapDif's

process in the FFE.

Conceptual Frame #2: Tomlinson's Concept Map of Differentiation

For the educational lens in the study, I used Tomlinson's (2014) visual

representation of the relationships between the principles and practices of differentiation

(Figure 15). As indicated on the map, a teacher who ascribes to the philosophy of

differentiation would ideally, then, ground her practice in a set of principles, which would

manifest in a set of non-negotiable practices. As the concept map indicates, a teacher

"differentiates" instruction when she modifies the content, process, product, or learning

environment in anticipation of, or in response to, varied student needs (Tomlinson 2014).

These needs can be conceptualized and addressed in three broad ways: A teacher can

match instruction or tasks to a student's current understanding about a topic or skill

(readiness), tap into the motivational power of a student's curiosity (interests), or consider

preferences a child may have for "taking in, exploring, or expressing content" (learning

profile) (Tomlinson & Imbeau, 2010, p. 17).

Figure 15. Concept Map of Differentiation. Reprinted from *The Differentiated Classroom* p. 25), by Carol Tomlinson, 2014, Alexandria, VA: Association for Supervision, and Curriculum Development, 2014

This schema uses the language of differentiation to illustrate the key concepts on which we based our AdapDif solution. The prototype build during Stage I supports the principle that instruction should respond to student variance, specifically the practice of

flexible grouping (i.e., GroupMat tool) and *proactive planning to address readiness,*

interest, and learning profile (i.e., Survey tool). The system also addresses other

underlying principles less explicitly:

- *Environment is a catalyst for learning.* AdapDif encourages teachers to

  connect with students, to know them better, and to send the message that they

  are interested in them. The Quick Note and Survey tools support this

  systematic study of students and encourage teacher sensitivity by providing a

  space to collect observations about students. Tomlinson (2014) explicitly

  recommends carrying a clipboard or tablet to record observations while

  observing students in class to use later for planning..

- *Assessment informs teaching and learning.* By encouraging teachers to elicit

  information about students, AdapDif hopes to position teachers to provide

  instructional responses to assessed student needs. The Survey tool supports

  ongoing assessment by allowing teachers to proactively elicit student

  responses, which can range from their interests and learning preferences to

  misconceptions, or where they are relative to learning goals. Teachers can use

  the tool for formative assessment, which can be used to inform data-driven

  decision-making.

- *Instruction should be a response to assessed student needs*. AdapDif does not

  yet offer instructional suggestions, but the system does connect students'

  Survey question responses to the GroupMat. This functionality implies

  student data should inform instruction. The GroupMat also provides (a) a

workspace to conceptualize patterns in student study, and (b) a mechanism to

distribute varying instructions to groups that have been created based on the

patterns in the data.

Tomlinson's model is described only briefly here as a conceptual frame; because it also

provides the foundational principles for both the problem of practice and AdapDif's

mission, differentiation is explored more deeply in the next chapter.

Literature Review

The exploratory nature of this capstone dictates "it is hard to predict which literature will be the most relevant" (Marshall & Rossman, 2006, p. 47). Still, bodies of literature exist that support the line of logic driving this study: (a) Differentiation is both a conceptual framework and a practice, both based on research, (b) teachers struggle to implement the principles and practices of differentiation—and we can speculate why— and (c) technologies like online professional development or adaptive software have been heralded as the antidote to these struggles (e.g., Dirin & Lane, 2018). Because this exploration also involves AdapDif's journey in developing its own technological solution, literature from product innovation and development provides context for the application development part of the study.

Differentiation Framework

Tomlinson's (2014) model of differentiation drives the development of AdapDif because, it a pedagogical framework, grounded in many fields of research, while also providing an all-encompassing, hands-on approach teaching and learning—it is concurrently theoretical, practical and philosophical.

Philosophy. At its most noble, differentiation is more than a list of strategies or even a set of principles: "Differentiation is rooted in and asks practitioners to grow in the ability to dignify human potential" (Tomlinson, 2014, p. 36). Philosophically, differentiation is rooted in the concepts of equity-as-access to opportunity and growth. The educational landscape is rich with voices calling for equity from the realms of policy (e.g., Darling-Hammond, 2015) to pedagogy (e.g., Thomas, Porfilio, Gorlewski, & Carr,

2014) to technology (e.g., Office of Educational Technology, 2017). This imperative of

equity is coupled with a firm belief in the malleability of students' intelligence and

potential to grow (Dweck, 2008). Tomlinson and Imbeau (2010) underscore the

importance of both engendering a growth mindset in both students and teachers in order

for the principles and practices of differentiation to be successfully applied. In short,

"differentiation is a model designed to guide teaching that provides equity of access to

excellence for every student" (Tomlinson, 2014, p. 27).

Principles. Differentiation takes a systematic view of the classroom in which

effective teaching depends upon the interdependent functioning of elements—learning

environment, assessment, curriculum, instruction, and classroom leadership and

management (Tomlinson & Moon, 2013). The principles that Tomlinson articulates

around these elements (see Figure 16) emerge from several bodies of literature about how

people learn (Bransford et al., 2000; Hattie, 2006).

Environment is a catalyst for learning. Tomlinson (2003) suggests that a teacher

who builds a successful differentiated classroom will focus as much on the learning

environment (i.e., "both physical and affective attributes that individually and

cumulatively establish the tone or atmosphere in which teaching and learning take place")

as the curriculum and instruction (p. 37). To support the beliefs that (a) diversity is

normal and valuable, and (b) teaching and learning are about growth, Tomlinson

highlights the need for teachers to connect with students, engender a growth mindset, and
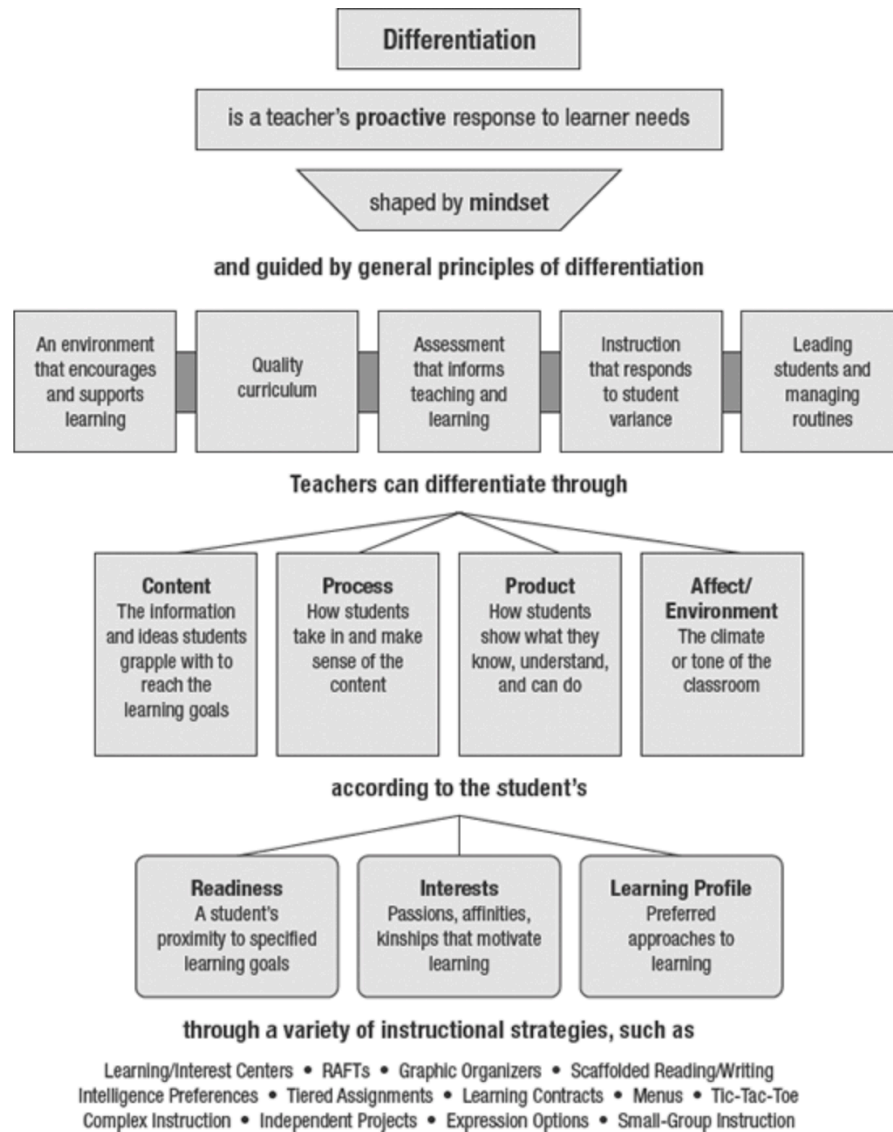
envision the classroom as a community.
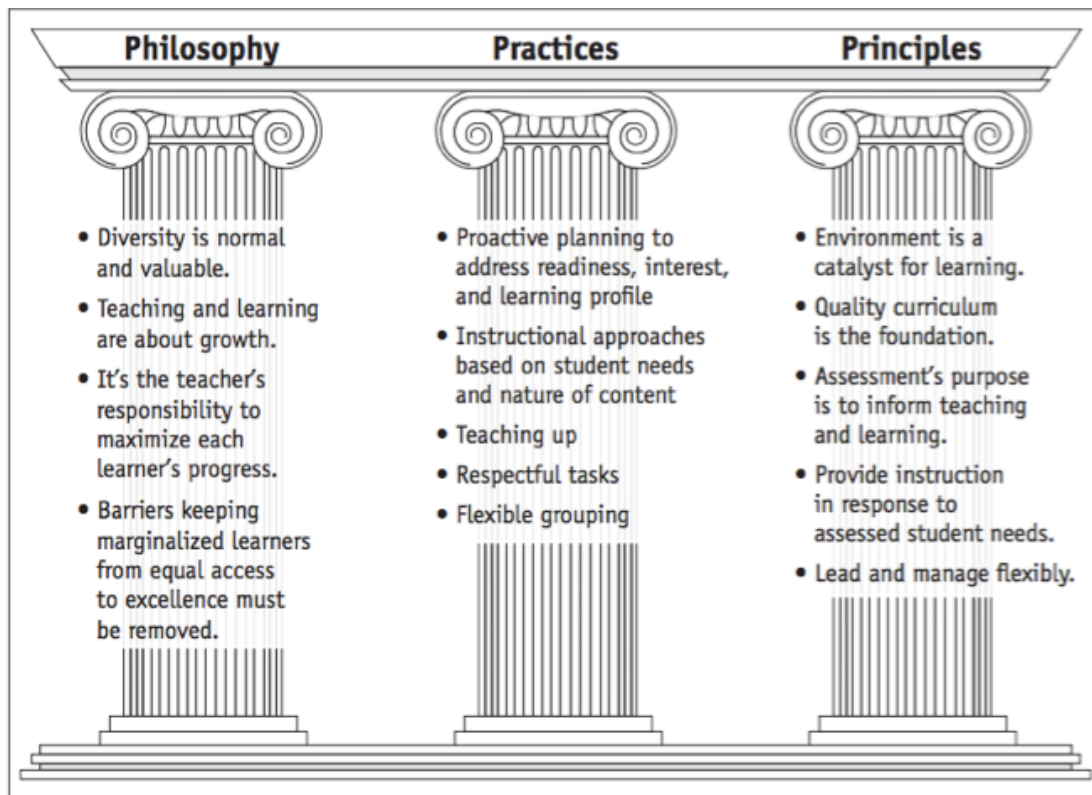
Figure 16. Three Pillars and Practices of Differentiation. Reprinted from *The Differentiated Classroom* p. 25), by Carol Tomlinson, 2014, Alexandria, VA:

Teacher-student connections. Like other researchers (e.g., Bransford et al., 2000; Sabol & Pianta, 2012), Tomlinson recognizes teacher–student connectedness as a critical dynamic in the learning environment. Researchers (e.g., Hatfield, Burchinal, Pianta, & Sideris, 2016) have amassed a large body of research that affirms the importance of what they call *teacher-student interactions.* Part of their research measures e*motional support* —classroom climate, sensitivity, and regard for students' perspectives (Pianta & Hamre, 2009)—and they have found positive impacts on student achievement through interventions with teachers that target their daily interactions with students (Allen, Pianta, Gregory, Mikami, & Lun, 2011; Gregory, Allen, Mikami, Hafen, & Pianta, 2014). This

research supports Hatttie's (2009) contention that teacher–student relationships are one of the most compelling influences in the classroom.

Mindset. A teacher's *mindset* sets the tone of a classroom and can shape how he or she responds to student differences (Tomlinson & Imbeau, 2010). The concept stems from Dweck's work on the relationship between implicit theories and the inferential practices associated with lay dispositionism, or "people's tendency to use traits as the basic unit of analysis in social perception" (Chiu, Hong, & Dweck, 1997, p. 19). Like an entity theorist, a lay dispositionist believes that "enduring dispositional traits" mediate behaviors (Chiu, Hong, & Dweck, 1997, p. 20). From this work on implicit theories (Dweck, Chiu, & Hong, 1993; 1995), mindset research follows a progression of investigation that explores the potential inferences each theorist-type might make. The longest-running theme in Dweck's work concerns theories of intelligence (e.g., Dweck & Leggett, 1988) and how they influence goals people pursue (Elliot & Dweck, 1988) as well as other "adaptive and maladaptive patterns" (Dweck & Molden, 2000, p. xii) ranging from school achievement (Henderson & Dweck, 1990) to neural responses to negative feedback (Dweck, Mangels, Good, Dai, & Sternberg 2004). Further studies extend to how these theories bear themselves out with regard to personality (Erdley et al., 1997), stereotype formation (Levy et al., 1998), and moral character (Chi, Hong, & Dweck, 1997). Dweck (2008; 2015) eventually streamlined her implicit theories concept into the construct of *mindset* in which she renamed entity theory, *fixed mindset,* and incremental theory, *growth mindset.*

Tomlinson and Imbeau (2010) write, "Differentiation is a growth mindset endeavor—it asks teachers to find an academic entry point relative to essential learning outcomes, to make instructional plans designed to move students to master of those outcome, and to adopt a 'whatever it takes' approach in doing so" (p. 33). In encouraging and embodying this mindset, the teacher strives to create a learning environment that values growth, operates from the belief that students can learn with hard work and support, and generates agency in students.

Classroom Community. According to Tomlinson and Imbeau (2010), a classroom that aspires to be a community is one in which students will ideally 1) learn to respect differences and empathize with others, 2) acknowledge the resultant variety of learning tasks to be fair, 3) trust the teacher who challenges them slightly beyond their comfort zone moves them fluidly between different groupings, 4) feel safe to make mistakes, and 5) occasionally construct learning cooperatively. Hattie (2012) asserts, "A positive, caring, respectful climate in the classroom is a prior condition to learning" (p. 70). Bransford et al. (2000) argue, too, that a classroom must be "community centered–because there is no one way from novice to proficient, so we need to share and learn from each other (particularly so that we can see and enjoy the trials and tribulations of how we each progress) and share the relevance in what we are aiming to learn" (p. 103). A classroom that establishes baseline of safety, trust, and respect is the first step in ensuring that differentiation thrives, and the teacher must be attuned to the needs (e.g., affective, cognitive, and physical) of all learners (Tomlinson & Imbeau, 2010).

Lead and manage flexibly. It is difficult to extricate the teacher from a

discussion of learning environment, especially given the significance of teacher-

relationships; however, the success of the learning environment also depends on how a

teacher comports herself and the structures she establishes. In short, Tomlinson (2014)

asserts teachers should "lead students and manage routines" (p. 20).

A differentiated classroom is a fluid; teachers establish a structure that allows for

both self-directed and collaborative student movement, as well as the "thinking space"

required to wrestle with big ideas. Integral to a positive climate is that students trust

"there is a reasonable degree of 'control'" and have confidence that interactions will be

"fair and in many ways predictable (especially when they ask for help)" (Hattie, 2012, p.

70). Tomlinson & Imbeau (2010) reiterate Hattie's contention and further assert that

students should collaborate with the teacher to understand the boundaries and nature of

that control. This is accomplished by

> talking through how this sort of classroom is both like and different from other
>
> classrooms they've been part of, figuring out what sorts of rules or guidelines will
>
> work best in such a classroom, thinking about the roles of teachers and students in
>
> the classroom, defining what "fair" will mean, clarifying the nature and role of
>
> quality work, and so on (Tomlinson & Imbeau. 2010, p.45).

A teacher establishes this balance of flexibility and control in an orderly environment, but

one that is enabling versus restrictive (Darling-Hammond & Bransford, 2007; Tomlinson

& Imbeau, 2014). In the more restrictive environment, the teacher tightly manages

routines and limits instructional strategies, effectively squeezing out the freedom needed

for instruction that invites sense-making. In fact,

> because the novel tasks required for problem solving are more difficult to manage
>
> than the routine tasks associated with rote learning, lack of knowledge about how
>
> to manage an inquiry- oriented classroom can lead teachers to turn to passive
>
> tactics that dumb down the curriculum (Doyle & Carter, 1987 in Darling-
>
> Hammond & Branson, 2007, p. 331).

By way of summing up his massive research efforts on teaching and learning, Hattie

(2014) assumes the voice of the ideal teacher in two sentences: "I see learning though the

eyes of my students; I help students to become their own teachers" (p. 5).

> ***Assessment's purpose is to inform teaching and learning/Instruction responds***

to assessed student needs. In order to effectively modify instruction, a teacher must

assess their students' readiness relative to learning goals (Tomlinson & Moon, 2013).

The concept of readiness is rooted in the Vygotskian concept zone of proximal

development (ZPD), "the distance between the actual development levels as determined

by independent problem solving and the level of potential development as determined

through problem solving under adult guidance or in collaboration with more capable

peers" (Vygotky, 1978, p. 33). Contemporary research not only supports this premise but

also suggests that teachers must continually determine the boundaries of that zone:

> Teachers must know where students are and aim to move them "+1" beyond that
>
> point; thus the idea of teaching the class as a whole is unlikely to pitch the lesson
>
> correctly for all students. This is where the skill of teachers in knowing the

similarities across students and allowing for the differences becomes so important

(Hattie, 2012, p. 97).

Ongoing assessment allows teachers to uncover these zones of student readiness,

and experts (Wiliam, 2011; Hattie, 2012) contend that the practice improves student

learning. Still, some debate exists about how to conceptualize formative assessment—is

it a process (Black & Wiliam, 1998; Looney, 2005; Tomlinson & Moon, 2013) or a type

of assessment (e.g. Kahl, 2005)? "Advocates of the process" (Bennett, 2011, p. 4)

articulate a core definition but with nuances: that formative assessment includes all

activities providing information to modify teaching and learning (Black & Wiliam, 1998),

that it takes place during learning (Cowie & Bell, 1999), that action is implied (Shepard

et al, 2005), or that it involves the students themselves and their progress (Stiggins,

2005). Formative assessment, however, is also often viewed as an entity, "a particular

kind of assessment instrument [rather] than a process by which instruction might be

improved" (Wiliam, 2011, p. 38). Problematically, when embodied in pre-made, interim/

benchmark assessments, these so-called formative assessments may or may not align to

classroom instruction or uncover "how students understand" (Christman et al., 2009, p.

2); hence, such assessments do not provide teachers with helpful data to inform their

instruction (Cosner, 2011). Awareness of this definitional cloudiness is important for

research purposes, because

> if we can't clearly define an innovation, we can't meaningfully document its
>
> effectiveness. Part of that documentation needs to be an evaluation of whether the
>
> formative assessment was implemented as intended, which we cannot accomplish

if we don't know what was supposed to be implemented. Similarly, if we can't

clearly define an innovation, we can't meaningfully summarize results across

studies because we won't know which instances to include in our summary. Last,

we won't be able to transport it to our own context, for how will we know the

characteristics on which to focus in doing the transport (Bennett 2011, p. 8)

Assessment experts (Moon, 2005, 2016; Pellegrino & Chudowsky, 2003) agree that

student learning improves when assessment, curriculum, and instruction are integrally

connected. Fluid use of formative assessment is paramount to the success of a

differentiated classroom (Tomlinson & Moon, 2013).

Quality curriculum is the foundation. Although it may in the future, the app

does not currently support teachers in creating high-quality curriculum, a significant

element in the differentiation system. Without clear learning goals, the teacher has

nothing against which to measure student readiness or interest, and, therefore, no

purposeful guide for modifying instruction. Without instruction driven driven by

essential understandings, the student has nothing that grounds their learning.

Clear learning targets. Researchers (e.g., Hattie, 2009) content that learning

intentions must be clear, challenging and outline not only skills (i.e. techniques and

methods) and knowledge (i.e. facts and concepts) but also understandings that will be the

"result of attempts by the student to make sense of the work and lessons, using inquiry,

performance and reflection" (Wiggins & McTighe, 2005, p. 58). In a synthesis of his

extensive meta-analyses, Hattie (2009) leaves no room for equivocation about the

articulation of learning goals:

> Teachers need to know the learning intentions [goals] and success criteria of their
>
> lessons [assessment], know how well they are attaining these criteria for all
>
> students, and know where to go next in light of the gap between students' current
>
> knowledge and understanding and the success criteria of: "Where are you
>
> going?" (p. 238).

Assessment experts (Chudowsky & Pellegrino, 2003; Moon, 2005; Stiggins, 2005;

Wilson & Sloane, 2000) also agree that student learning improves when assessment,

curriculum, and instruction are integrally connected. Practically applied, Tomlinson

(2014) recognizes goal clarity as the starting point from which to create pre- and

formative assessments; the results illuminate students' varied understanding relative to

those learning targets and ultimately, inform the instructional she designs.

Essential understandings. Experts in curriculum, instruction and assessment are

emphatic that learning be steeped in conceptual understanding (Bransford et al., 2000;

Erickson, 2007; Tomlinson, 2014; Wiggins & McTighe, 2005). Even without the benefit

of brain research Taba (1971) explained the relational purpose of what she referred to as

basic ideas and *principles* and what Wiggins and McTighe (2005) call *understandings*

that "give control over a wider range of subject matter, organize the relationships between

facts, and thereby provide the context for insight and understanding" (p. 213). Hence, in

creating learning goals to which instruction and assessment should align, it is paramount

that teachers begin, not only with objectives dictated by facts and skills, but also with

statements of understanding. The understanding goal is "an inference that makes

meaning of many discrete (and seemingly insignificant) elements of

knowledge" (Wiggins & McTighe, 2005, p. 43) thus meeting the brain's "hunger for

meaning" (Tomlinson, 2014).

Practices. These differentiation principles become actualized in a set of

classroom practices, explicated below.

Proactive planning to address readiness, interest, and learning profile. In a

differentiated classroom, the teacher uncovers patterns in her student population relative

to readiness, as well as interest and learning profile, and then modifies instruction in

response to those patterns.

Readiness. The practice of modifying instruction according to students'

readiness, their "entry point relative to particular knowledge, understanding, or skill,"

applies the reciprocal principles of *assessment informing teaching and learning* and

instruction responding to assessed student needs (Tomlinson, 2014, p. 18). Branford et

al. (2000) conceptualize learning in phases from *novice* to *capable* to *proficient*, and

students location on that continuum should inform instruction.

Interest. Teachers can also capitalize on the motivating power of a "learner's

affinity, curiosity, or passion for a particular topic or skill" (Tomlinson, 2014, p. 19).

Interest is understood to be a motivational variable in learning; hence, most studies focus

on distinguishing it from other motivational variables or examining the ways in which it

influences learning, such as attention (Ainley, Hidi, & Berndorff, 2002; Hidi, Renninger,

& Krapp, 2004) or goals (Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000; Durik &

Harackiewicz, 2003; Pintrich & Zusho, 2002), or developing theoretical models on how

interest develops (e.g., Hidi & Renninger, 2006; Johnson, Alexander, Spencer, Leibham

& Neitzel, 2004; Krapp, 2002; Silvia, 2001).

Two types of interest have relevance for instruction—situational (i.e., "focused

attention and the affective reaction that is triggered in the moment by environmental

stimuli, which may or may not last over time") and individual (i.e., "to a person's

relatively enduring predisposition to reengage particular content over time as well as to

the immediate psychological state when this predisposition has been activated") (Hidi &

Renninger, 2006, p. 113). Hidi and Rennigner (2006) suggest that, while situational

interest can be sustained through meaningful tasks (e.g., project-based learning,

cooperative group work) tapping into the more enduring power of individual interest can

elevate motivation and result in students generating their own questions about a topic and

propelling their own learning.

Learning Profile. The practice of modifying instruction based on learning profile

is an often misinterpreted piece of Tomlinson's model, perhaps because it concerns the

ways in which a student learns, a process that is eternally debated and studied

(Tomlinson, 2014). Tomlinson and Moon (2013) describe learning profiles as "preferred

approaches to learning … shaped by gender, culture, the environment, biology, and a

particular learning context" (p. 11). (Learning profiles refer to something different in the

context of personalized learning, discussed later in this review.) Previous iterations of the

differentiation model included learning styles in this list (Tomlinson, 1999), the research

about which has been challenged over the last 10 years (e.g., Willingham, Hughes, &

Dobolyi, 2015). In short, Tomlinson and Moon (2013) submit that differentiating with

learning profiles in mind should "create more ways for students to take in, engage with, explore, and demonstrate knowledge about content, and then to help students develop awareness of which approaches to learning work best for them under which circumstances, and to guide them to know when to change approaches for better learning" (p. 11).

Flexible grouping. Differentiation stems, in part, from an epistemology of social constructivism (Prudhomme, 2006; Vygostky, 1978), a perspective that characterizes learning as an interaction with the social and physical environment. As opposed to cognitive constructivists who separate the individual processing of knowledge from the social processes, Vygotsky "conceptualized development as the transformation of socially shared activities into internalized processes" (John-Steiner & Mahn, 1996, p. 192). In the early stages of learning, learners depend on more experienced others but "take on increasing responsibility for their own learning and participation in joint activity" (p. 192).

Taking into account both the socially constructed nature of learning and the natural patterns in student data, a teacher differentiating instruction will often create small groups. Teachers who plan instruction responsively will flexibly group students, planning "a consistent flow of varied student groupings within a unit of study based on the nature of the work and the individual needs of students" (Tomlinson 2012, p. 90). A teacher will engage in both readiness grouping and heterogeneous cooperative grouping (Cohen, 1994; Cohen & Lotan, & Holthuis, 2013; Slavin, 2010) with the understanding that these configurations should not be static. The difference between small group

instruction and flexible grouping is the purposeful and constant regrouping of students.

Intentional grouping by the teacher, based not only on readiness, but also interest or

learning profile, provides multiple contexts both for the learner to view themselves and

for the teacher to observe the learner (Tomlinson 2012). The incorporation of both types

of grouping contributes both to the cognitive and affective needs of the individual and the

class.

   Teaching Up & Respectful Tasks. Perhaps more abstract, but equally important

to the holistic view of successful differentiated classroom, are the practices of *teaching*

up and creating *respectful tasks.* Both are rooted in the notion that all students deserve

access to engaging and meaningful learning. The former concerns the level at which a

lesson is pitched. Tomlinson and Moon (2015) suggest,

> If teachers routinely began planning student work by developing tasks that would
>
> invigorate students who are advanced in a topic or content area and then
>
> differentiate by providing scaffolding that enables the range of less advanced
>
> learners to work successfully with the advanced-level task, achievement would
>
> be accelerated for many other others (p. 8).

In creating scaffolding, a teacher who is reinforcing that same belief in equity will

demonstrate high expectations for all students by creating tasks that are equally respectful

and by providing access to the same important ideas and inviting higher-level thinking.

   The power of teacher expectations is historically well-represented in educational

research (e.g., Harris & Rosenthal, 1985; McKown & Weinstein, 2008; Rubie-Davies,

2006; Rubie-Davies, Hattie & Hamilton, 2006; Stipek, Feiler & Milburn, 1995). For

example, Bohlmann and Weinstein (2013) recently confirmed that teachers beliefs about

a student can manifest in their instructional practice and shape students self-perceptions

about their ability. The study revealed

when differential teacher expectations are made salient through ability-based practices,

students come to know where they stand in the classroom achievement hierarchy,

creating a self-perception gap between those who are the recipients of high versus low

teacher expectations. The evidence here shows alignment between teacher and student

perceptions of math ability in ability-differentiated classrooms but not in more equitable

classrooms.

Because a teacher's expectations are so impactful to a student, and because

instructional tasks imply those expectations, these practices must exist in order for the the

differentiated classroom to succeed.

Impediments to Successful Differentiation

As the problem of practice suggests, differentiation is an ongoing challenge for

teachers, especially to apply principles and practices with fluidity and sophistication.

Some critics have responded to this challenge with vehemence, claiming that

differentiation, as they understand it, is insurmountable (e.g., Delisle, 2015), based on

unsound research (i.e., by conflating differentiation with learning styles; Reiner &

Willingham, 2010) or too complex and without enough perceived reward (Marshall,

2016). While the pros and cons continue to be debated (Robb & Bucci,. 2015), the

purpose of this study is not to argue to merits of differentiation. Rather, it is to explore

how an app might assist teachers as they attempt to enact the (research-based) principles

discussed thus far in this review.

In fact, finding a way to attenuate teachers' struggle with differentiation is

AdapDif's mission. If the cause of that struggle were unequivocal, the solution would be

as well. This section explores the research behind some of the skills, knowledge, and

dispositions that may play a part in that struggle. These include teachers' use of data to

inform instruction, degree of pedagogical knowledge, and opposition to teaching

practices related.

Using data to inform instruction. To capably modify instruction according to

students' demonstrated readiness, interest or learning preference, a teacher should be

adept at translating data into instructional action. This ability has been termed

*instructional decision makin*g (Means, Chen, DeBarger, & Padilla, 2011) or *pedagogical*

data literacy (Mandinach, 2012), the later combining a teacher's pedagogical content

knowledge with their understanding of how data can and should drive instruction.

Mandinach and Gummer (2013) have suggested an almost chicken-and-egg relationship

between data literacy and differentiation: They list the ability to differentiate instruction

as an undergirding process of data literacy, while they concurrently identify other key

processes in data literacy that are, in fact, inherent to differentiation, such as the ability

to:

- formulate hypotheses about students' learning needs and instructional

  strategies;

- collect and use multiple sources of data;

- modify instructional practice according to the data collected;

- focus on all children, not just the "bubble kids";

- look for causes of failure that can be remediated (p.32).

Teacher's pedagogical data literacy could, in fact, impede differentiation, and research suggests teachers' use of data varies wildly depending the context and teachers' beliefs about the utility of data (Datnow & Hubbard, 2015). Wininger & Norman (2005) have found that teachers inconsistently understand how assessment should inform instruction and that some teachers recognize the importance of formative assessment yet still do not engage in it; in fact, some consider formative assessment to be "beyond their normal instructional obligations" (Young & Kim, 2010, p. 6). This data dissonance can be exacerbated by standardized assessments: Because items on these tests do not reveal the causes of student misunderstanding, teachers often struggle to use the resultant data to inform their instruction (Christman et al., 2009). Furthermore, the distance of these benchmark data from the classroom inhibits their utility (Cosner 2011; Schildkamp & Kuiper, 2010) and can result in teachers focusing on struggling students, often "bubble students" who hover at the passing mark (Blanc et al., 2010; Christman et al., 2009; Cosner, 2011; Nabors Oláh et al., 2010; Shepard et al., 2011).

Researchers (e.g., Datnow & Hubbard, 2015; Little, 2012; Nabors Oláh et al., 2010) have suggested that more research is needed on how data literacy manifests in the classroom, particularly how teachers analyze, and more importantly, act upon data. The small number of studies that do delve into this area lack observational data and rely upon self-report data (e.g., Blanc et al., 2010; Christman et al., 2009; Cosner, 2011; Davidson

& Frohbieter, 2011; Datnow & Park, 2014; Hoover & Abrams, 2013; Nabors Oláh et al.,

2010; Pierce & Chick, 2011), while others involve teachers making sense of large data

sets (e.g. Means et al, 2011). In recent study using teacher interviews, researchers found

that the majority of teachers did not alter their instruction based on data (Farrell & Marsh,

2016).

        Degree of pedagogical content knowledge. Another possible impediment to

differentiation may be teachers' pedagogical content knowledge, "that special amalgam

of content and pedagogy that is uniquely the province of teachers, their own special form

of professional understanding" (Shulman, 1986, p. 8). Embedded in this concept is

importance of content knowledge:

> [K]nowing a subject for teaching requires more than knowing its facts and
>
> concepts. Teachers must also understand the organizing principles and structures
>
> and the rules for establishing what is legitimate to do and say in a field. The
>
> teacher need not only understand that something is so; the teacher must further
>
> understand why it is so, on what grounds its warrant can be asserted, and under
>
> what circumstances our belief in its justification can be weakened or denied.
>
> Moreover, we expect the teacher to understand why a particular topic is
>
> particularly central to a discipline whereas another may be somewhat peripheral
>
> (Shulman, paraphrased in Ball, p. 391).

Researchers (Aschbacher & Alonzo, 2004; Duschl & Gitomer, 1997; Fennema, Franke,

Carpenter, & Carey, 1993) have suggested that teachers who have strong grasp of their

content can recognize where a student is in a learning progression and adapt to that

location. Researchers on data literacy (e.g., Oláh, Lawrence, & Riggan, 2010) found that

teachers' personal "thresholds" for mastery of the content influenced how they interpreted

data. In fact, this pedagogical data literacy—the ability to make instructional decisions

from data—combines both pedagogical content knowledge and understanding how

interpret and use data to make instructional decisions (Hamilton et al., 2009; Mandinach,

2012). In short, the more facile a teacher is with her content, the more potential she may

have to not only spot misconceptions and adjust instruction, but also to extract clear and

meaningful content goals from standards and generate essential understandings on which

to base instruction.

Teacher opposition. Finally, teachers' objection to some of the differentiation

processes may be an impediment to executing differentiation. For example, some

teachers struggle with small group instruction (Cooper, MacGregor, Smith, & Robinson,

2000; Wyatt & Chapman-DeSousa, 2017). Research has shown that secondary teachers

are less likely to use small group instruction (Baines, Blatchford & Kutnick 2003; Race

& Powell, 2000). When teachers do put students in groups, they are often grouped to

maintain control or keep students on task (Baines, Blatchford & Kutnick 2003) or are

grouped by convenience without instructional intent (Gillies, 2003, 2008).

Another more deep-seeded impediment may involve teacher's beliefs. A study

that explored a large-scale implementation of differentiation found that

> learning to differentiate entailed more than simply learning new practices. It
>
> required teachers to confront and dismantle their existing, persistent beliefs about
>
> teaching and learning, beliefs that were in large part shared and reinforced by

other teachers, principals, parents, the community, and even students. The

combination of the inherent complexity of differentiation with the ingrained

nature of traditional deep structure beliefs about school often made encouraging

large-scale changes in most teachers' practices difficult, if not impossible

(Brighton et al., 2005, p. 306).

Asking teachers to reexamine their beliefs about teaching is no small task. Tomlinson

and her colleagues (2008) have acknowledged that shifting teachers from traditional

instruction to responsive, differentiated classrooms requires second-order change. Unlike

first-order change that can exist with current paradigms, second-order change describes a

magnitude of change that conflicts with "prevailing values and norms" (Marzano, Waters

& McNulty, 2005, p. 8). Ultimately, this kind of change "asks teachers to alter beliefs

and practices – often dramatically" (Tomlinson & Imbeau, 2010, p. 23).

Technology as Solution

We formed AdapDif to investigate technological solutions to respond to the

challenges surrounding differentiation. In the realm of online technology,

personalization is often used as a proxy for differentiation or is offered as an alternate,

online solution. As such, it is important to make distinctions between the two.

Differentiation has been swept into the language of personalization as advocates

for new technologies (e.g., big data mining, algorithmic computation, learning analytics,

and adaptive learning systems) claim classrooms can be transformed into more equitable

and student-centered places via technology. Tomlinson (2017) notes that scholars have

not yet come to a consensus on how to define personalization, while policymakers and

stakeholders in the private sector (i.e., software companies) seem to have operationalized

it in technological applications/products. For example, the U.S. Department of

Education's Office of Educational Technology (2017), the body who establishes the

national educational technology vision and agenda, defines personalized learning as

> instruction in which the pace of learning and instructional approach are optimized
>
> for the needs of each learner. Learning objectives, instructional approaches, and
>
> instructional content (and its sequencing) all may vary based on learner needs. In
>
> addition, learning activities are meaningful and relevant to learners, driven by
>
> their interests, and often self-initiated (p. 9).

Personalization, so defined, overlaps somewhat with differentiation (i.e.,

instructional approaches optimized according to student need, meaningful and relevant

learning activities). However, when envisioned by tech companies, personalization

seems to veer from the heart of a differentiated classroom. The variety of learning

objectives and individualized pacing hints at a classroom and school structure, not as

interactive hive of socially constructed knowledge guided by teacher instinct and

wisdom, but instead as a circuit board of individualized learner pathways, patrolled by a

teacher/data-manager. Privately funded school-wide initiatives to promote personalized

learning hone that vision more acutely. In an evaluation of three initiatives from the Bill

and Melinda Gates Foundation (e.g., Next Generation Learning Challenges (NGLC),

Charter School Growth Fund's Next Generation School Investments, and the Gates

Foundation's Personalized Learning Pilots) researchers (Penuel & Johnson, 2016)

organized personalized learning according to five strategies:

- learner profiles with individualized goals using data from multiple sources that students and teachers both access;

- personalized learning paths, in which students have choice, get individualized support, and engage in learning outside school;

- competency-based progression;

- flexible use of time, space, and technology; and

- developing academic and non-academic career and college readiness skills (p. 3).

Personalization in the hands of product developers becomes realized through algorithms and analytics. Learner profiles become *adaptive learner profiles* that "adapt" to the data collected as a student passes through school. Data can range from demographics and cognitive measures to measures of affective disposition (e.g., levels of frustration, motivation, confidence, boredom, and fatigue) and behavioral task performance (i.e., measured by biometric sensor systems) (Shechtman, DeBarger, Dornsife, Rosier, & Yarnall, 2014). Potentially then, learning analytic researchers (or systems) use data to "make predictions about learning performance, suggest relevant learning resources, detect undesirable learning behavior, detect the affect of learners (Verbert et al. 2012), to personalize and adapt content (Siemens 2013), and to detect at-risk learners (Macfadyen & Dawson, 2010)" (Roberts-Mahoney, Means & Garrison, 2016, p. 413). These predictions are made either by a rule-based system (i.e., an if-then schema whose complexity depends upon the complexity of the branching of choices) or

an algorithm-based system that uses mathematical functions. The latter is far more

complex and

> involves machine learning capabilities, where the system learns more and more
> about the student and content as it goes along. This enables it to pair the two
> more effectively. Such systems may make use of educational data mining and
> advanced analytics to deal with big data, and employ complex algorithms for
> predicting probabilities of a particular student being successful based on
> particular content. These algorithm-based systems gain in complexity based on
> the ways in which they might classify a student and classify content, and the
> number of variables they consider (Oxman & Wong, 2014, p. 17).

Critics of personalized learning (Roberts-Mahoney, Means & Garrison, 2016) cast

it as a tool of the corporate reform movement of schools. Using document analysis (i.e.,

of U.S. Department of Education reports, personalized learning advocacy papers, and

learning analytics research monographs), Robert-Mahoney and his colleagues (2016)

studied how "prominent 'personalized learning' narratives: (1) conceptualize the purpose

of education; (2) conceptualize the role of data in education; (3) conceptualize the role of

the teacher; (4) and conceptualize learning" (p. 408). In their analysis they cautioned that

these narratives treat personalized as "a superior form of classroom authority, rendering

both non-educators and computer algorithms as more credible than teachers" (p. 413) and

reduce learning to the "development of discrete skills" (p. 414). While Roberts-

Mahoney, Means and Garrison emphasized personalized learning as a tool that shifts the

authority from public schools to the private sector, they also warned that "personalized

learning technology favors reductionist, mechanistic, linear, anti-intellectual, anti-

relational, and prescriptive approaches to teaching and learning" (p. 416).

Ultimately, personalization and differentiation seemingly share similar purposes:
to "disrupt" the one-size-fits-all paradigm of instruction and advocate for learning that
emanates from individual child's needs. What differs, perhaps, is how each approach
proposes to accomplish these goals. It remains to be seen how personalized technologies
will effectively integrate into a differentiated classroom where the teacher is valued for
her expertise and leadership in the classroom. In an article entitled, "Let's Celebrate
Personalization: But Not Too Fast," Tomlinson (2017) suggests that personalization is
actually "a kind of differentiation—or perhaps multiple kinds" (para 27).

These conceptions of personalization are relevant to the study of an ed tech start-
up primarily as they impact funding. For example, the Office of Educational Technology
sets the innovation agenda which, in turn, influences funding priorities of federal
agencies (e.g. IES, NSF) who fund start-up ventures. Furthermore, the perception from
the market influences what private investors understand and support; terms like
personalization and *big data* inevitably become part of the current conversation for an ed
tech start-up, especially one that purports to be student-centered or pattern-seeking.

Research Questions

The underlying goal of this capstone was to consider the question, "How can the
affordances of technology be leveraged to create, facilitate and/or support a differentiated
classroom?" The search for that answer will result in: 1) a concrete set of
recommendations for the development of pedagogically sound and usable technology,
and 2) action items for AdapDif based on those recommendations. The following two
research questions shaped the study:

1. What can be learned in the development process of an educational technology

   with a pedagogical mission?

2. In what ways do teachers engage with an online tool designed to support their

   attempts to differentiate instruction?

Methods

I segmented the research undergirding this Capstone into two phases: AdapDif's

Development (Phase I) and Prototype-Testing (Phase II). This chapter explicates the

methodology employed, first by explaining the research design (with Phase I and II data

sets described separately) followed by data analysis procedures for both phases, which

overlap.

Design

While methodologists (e.g., Merriam, 1998; Stake, 1995; Yin, 2002) quibble over

the nuances of defining and conducting case studies, most broadly agree that a qualitative

case study allows for the flexibly structured exploration of a bounded phenomenon.

There are two phenomena under consideration in this Capstone with one embedded

within the other: The encompassing phenomenon is that of creating an educational

application supporting differentiation; the subsumed phenomenon is how teachers use

that technology (see Figure 17). The first phenomenon, AdapDif's development process,
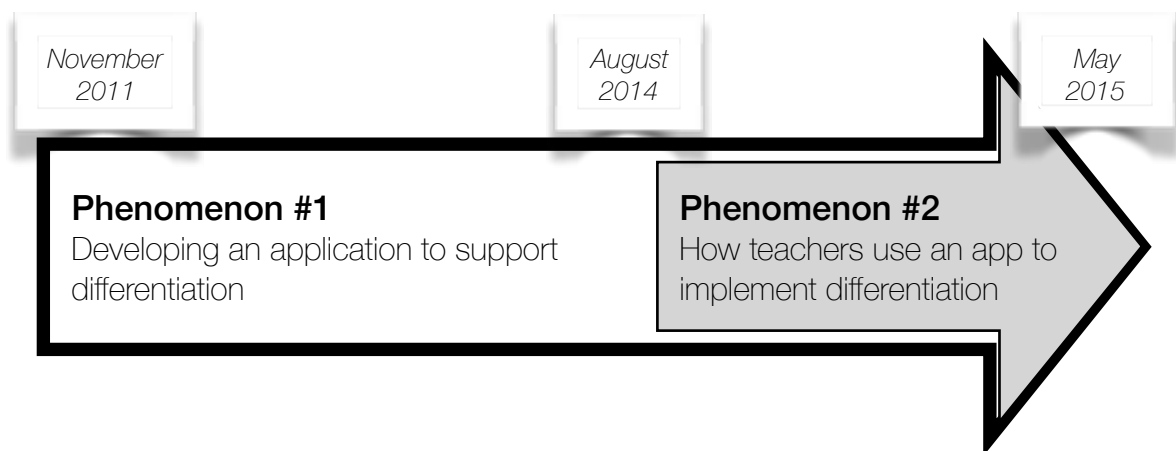
Figure 17. Illustration of the two, bounded phenomena being explored.

is bounded by a timeline that begins with the conception of an online technology (i.e.,

November, 2011) and ends in the development of a prototype (August 2013–May 2015).

The subsumed phenomenon is bounded by the beginning and ending (August 2014-May

2015) of user testing that occurred toward the end of development.

In selecting an appropriate case study approach, I considered Stake's (1995)

classifications: A case study is instrumental when the case is intentionally selected to

understand a "puzzlement" or research question and thus becomes instrumental to our

inquiry, and intrinsic when the case is predetermined and our interest in it particular and

intrinsic (p. 3). This Capstone was guided by research questions requiring two slightly

RQ#1: "What can be learned in the development process of an educational technology with a pedagogical mission?"

PHASE I
Development
Intrinsic case

PHASE II
App testing
Instrumental

RQ#2: In what ways do teachers engage with an online tool designed to support their attempts to differentiate instruction?

Figure 18. Capstone Case Study Design: Phases I and II represent different strategies of inquiry (i.e., one intrinsic, the other instrumental) and attend to separate research questions.

different strategies of inquiry, and as a result, involved both case types (instrumental and

intrinsic) and two phases of the research, illustrated in Figure 18.

A case study approach also aligns with new product development (NPD) practices

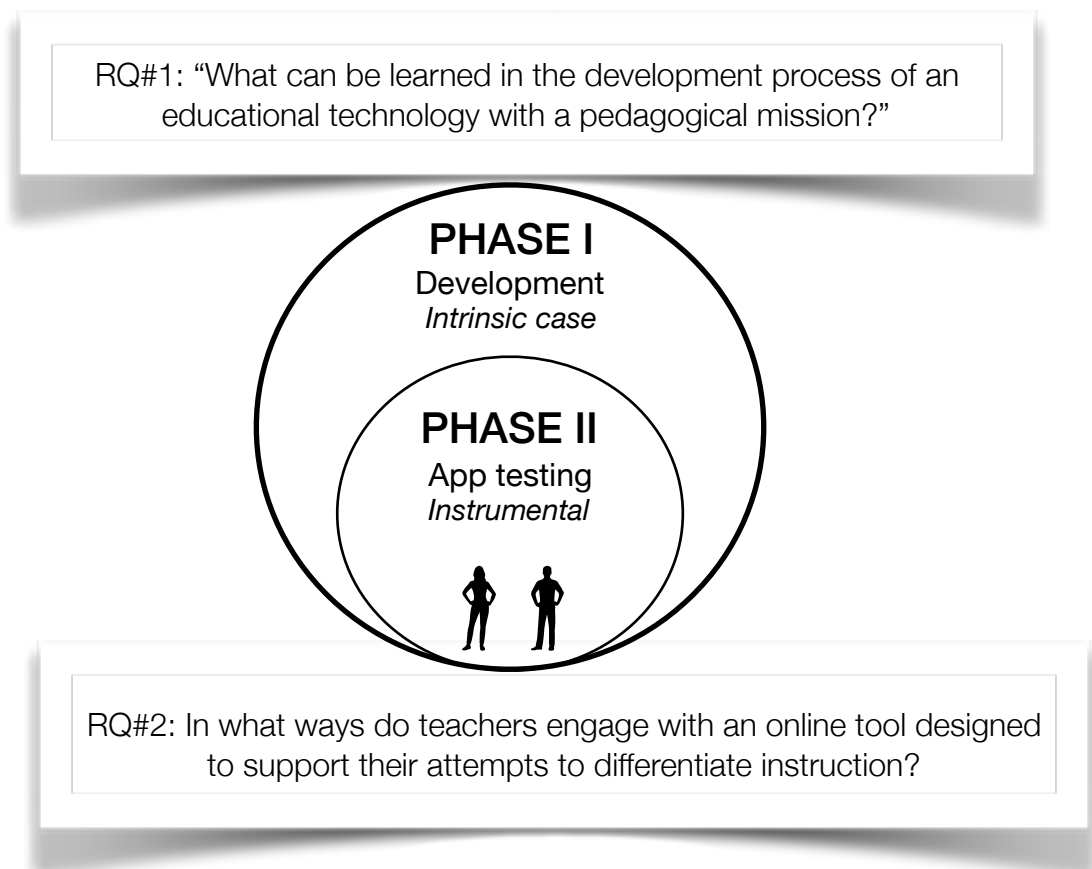(Kahn et al, 2013) which encourage interaction between user and developer to increase

product innovation (e.g., Kristensson, Reid, Gustafsson, & Archer, 2004) and allow

traditional research methods and usability approaches to coexist comfortably.

Phase I: AdapDif development process. In order to unpack the first research

question, "What can be learned in the development process of an educational technology

with a pedagogical mission?" I examined the process of creating an educational

application as experienced by AdapDif. The analysis of this experience was by its nature

intrinsic—the conclusions were particular to this unique case.

Data collection. The data collected in Phase I were archival and consisted of

documentation of AdapDif's development process. These data were housed on the

company servers (e.g., Google Drive, Dropbox, AdapDif email, and Evernote) and

ranged from internal documents (e.g., minutes taken during company meetings and

design iterations) to external documents (e.g., grant applications). The data were

delimited by the company's inception at the Curry Cup in November 2012 to prototype

testing which concluded in May of 2015. Table 1 provides an overview of the data

sources, explained below. Examples of each data source can be found in Appendix A.

Meeting notes. A member of the AdapDif team recorded notes in Evernote during

meetings that occurred with varying frequency. During the most intensive period, the

iLab Accelerator (May 2013–August 2013), meetings occurred daily. These notes traced

Table I _Phase I: Development Process Data Sources_			
Source	Explanation	Total	Location
Meeting notes	Concept development notes		Evernote
Pre-iLab	Meeting minutes, general notes	125	
iLab Accelerator	Meeting minutes, general notes	222	
iLab Incubator	Meeting minutes, general notes	17	
During Pilot		97	
Wireframes	Digital sketches of design ideas made in	13	Balsamiq Mockups
Pitches & Presentations	Keynote and powerpoints		Google Drive
Federal grant applications	Funding attempts through IES, NSF	3	Google Drive

the team's thinking as they developed the application and as they attended required

meetings within the iLab and with external advisors.

Wireframes. Design ideas were visually communicated to the programmer

through wireframes, digital blueprints that translate conceptual structures into a concrete

user interface. These page layouts were designed in Balsamiq Mock-Ups, a wire-framing

software that reproduces the experience of sketching on a whiteboard or on a computer.

Pitches and presentations. AdapDif created multiple keynote presentations for

potential investors and entrepreneurial competitions. Archived keynote and powerpoint

presentations were data sources from these pitches.

Federal grant applications. AdapDif applied for three federal grant applications,

two funded by the the Small Business Innovation Research (SBIR) program and one from

the Department of Education's Institute of Education Sciences (IES), in an attempt to

fund further development. The extensive documentation generated from this process

included the proposals themselves as well as the responses from the review boards.

Phase II: App Testing. Data in Phase II were collected during prototype testing,

conducted as a part of a study, approved by the University's IRB-SBS (e.g.,

Differentiation Technology: A Pilot Study). Testing was open to a group of teachers who

were formally identified through Curry contacts and professional development

interactions. From a group of 15, two teachers were selected to study more

systematically. I contacted both teachers via email in July 2014 to ask if they were

interested in testing the app during the upcoming school year, and both responded

favorably. Data collection began in August 2014, and included email exchanges, backend

data from the app, classroom observations, interviews, and artifacts. These data were not

analyzed at the time. Phase II of this Capstone involved the analysis of the archival data

collected in that study, a brief description of which follows.

Phase II User Study Description. The purpose of the study was to investigate

how teachers interacted with AdapDif's application, built to support classroom teachers

implement some key practices of differentiation—taking notes about students' interests

and learning preferences, conducting ongoing assessments about students' readiness and

interests, and grouping students according to patterns in data. From a research

perspective, the study's intent was to supplement the growing, but by no means

comprehensive, body of literature on how teachers use technology in their classrooms as

well as what impedes and supports their efforts to differentiate instruction. From the

company's perspective, the purpose was simply to uncover bugs in the programming and

to observe how teachers interacted with the online application with limited guidance, the

results of which would determine how to create a more viable product. This user-testing

study was guided by the following research questions:

1) What are the affordances and limitations of an online tool designed to support

teachers attempting to differentiate instruction?

2) To what extent does the tool cause teachers to reflect on their instructional

practice?

3) How might the tool be adjusted to better support teachers in differentiating

instruction?

As a user study, these research questions have an evaluative, actionable tone, and

so, for the Capstone, they were subsumed into the more broad question, "In what ways do

teachers engage with an online tool designed to support their attempts to differentiate

instruction?"   The discussion chapter addresses the teachers' reflections, and the

implications and recommendations from the Capstone include general suggestions about

AdapDif's next step to better support teachers.

Site and Participants. After securing permission from the school district and the

University of Virginia's Institutional Review Board, I conducted research in middle and

high school classrooms (based on secondary students' more consistent access to and

interaction with laptops and/or mobile devices). The two schools included a middle and

high school in a Mid-Atlantic school division with a total enrollment of approximately

13,800 students. Demographic subgroups broke down as follows: 62% White, 13%

Hispanic, 11% Black, 29% "disadvantaged" (i.e., students eligible for free or reduced

lunch), and 10% Limited English Proficiency.

      The demographics of the middle school site reflected a slightly more diverse

picture than the district as a whole: 47% White, 20% Hispanic, 19% Black, 45%

"disadvantaged," and 22% Limited English Proficiency. The high school, on the other

hand, was more homogenous with the student body comprised of 87% White, 4%

Hispanic, 3% Black, 9% "disadvantaged," and 1% Limited English Proficiency.

      Two participants were chosen from a pool of teachers (e.g., attendees of

conferences on differentiation hosted by Institutes on Academic Diversity at the

University of Virginia or teachers who have taken courses at Curry) who expressed

interest in using technology, specifically this online application, to differentiate their

instruction in the classroom. One, a middle school Language Arts teacher and the other, a

high school teacher from the Social Studies department, were ultimately chosen because

(a) their students had consistent access to a device (e.g., computer or tablet) in their

classrooms via a one-to-one initiative or a computer cart, (b) they were willing to help

identify bugs during the early phases of product development, and (c) they articulated a

desire to improve their understanding of differentiation practices.

      Mr. Grayson, an experienced high school teacher, had been teaching "on and off"

in the district since 2001. He taught for one year at a private school with a B.S. degree in

Political Science, after which he earned a PG/MT (i.e., a post-graduate program/Masters

of Teaching for students who have already completed an undergraduate degree) and

student-taught in the district and school where he worked. When he agreed to pilot the

app in July of 2015, he believed he would be teaching five sections of Government to

seniors (e.g., four Advanced and one AP) and one section of World Geography to

freshmen. His interest in using the app coincided with his stated goal that year of trying

to know his students better, as he did when he first started teaching (observation,

1/30/15).

In her 14th year of teaching at the time of the study, Mrs. Morrison had expressed

interest in making differentiation her Smart Goal for that school year. Prior to working in

this district, she taught 4th and 5th grade across subjects and had begun her career

teaching four-year-olds in a preschool. She had taught in a university lab school, held a

teaching license in elementary and early childhood education, and was a few classes short

of a Master's degree. She was in her seventh year teaching at the middle school and was

teaching only one subject, 6th grade English/Language Arts, broken into in three tracks—

advanced, standard, and standard/collaborative—in 100-minute blocks.

While both teachers were experienced and confident educators, they had each

actively sought support or further education on differentiation. Mr. Grayson had attended

a three-day workshop on differentiation, and Mrs. Morrison had requested support from

her district administration the prior year on using MAP data to differentiate instruction.

Although it can be argued that these two cases were chosen for convenience (e.g., their

willingness to test the application), they were intentionally selected to unpack the

research questions concerning how teachers use educational technology (e.g., In what

ways do teachers engage with an online tool designed to support their attempts to

differentiate instruction? In what ways do teachers engage with an online tool designed

to support their attempts to differentiate instruction?) based on their expressed interest in better understanding and applying differentiation to their classrooms. They were, hence, instrumental to the inquiry, and this criterion sampling strategy (Patton, 1990) suggested these subjects would provide information-rich cases.

Data collection. Data collection lasted approximately 10 months (August 2014–May 2015) and occurred in two loose stages—unguided/unobserved app use and guided/observed app use. The bulk of data were gathered during the second stage. See Appendix B for a visual map of data collection.

Unguided app use. Caner created teacher accounts in the system for both teachers in August. To facilitate smooth onboarding onto the app, AdapDif offered to import class rosters for teachers via the backend of the app. Teachers were then free to explore the set of tools built into the application without guidance from AdapDif for the remainder of the semester. Interactions with teachers during this phase were limited so that (a) we might discover how teachers would use the application without interference and (b) "bugs" and functionality issues could be uncovered. Teachers' usage was loosely tracked using an online application called Mouseflow (mouseflow.com) which records user activity (e.g., clicks, mouse movement, and scrolls). Users communicated issues and questions through email and through a product feedback management software feedback tool (Uservoice, 2014 version) into the AdapDif application (see Figure 19). When they reported bugs which rendered the application unusable, the AdapDif programmer fixed them as quickly as possible.
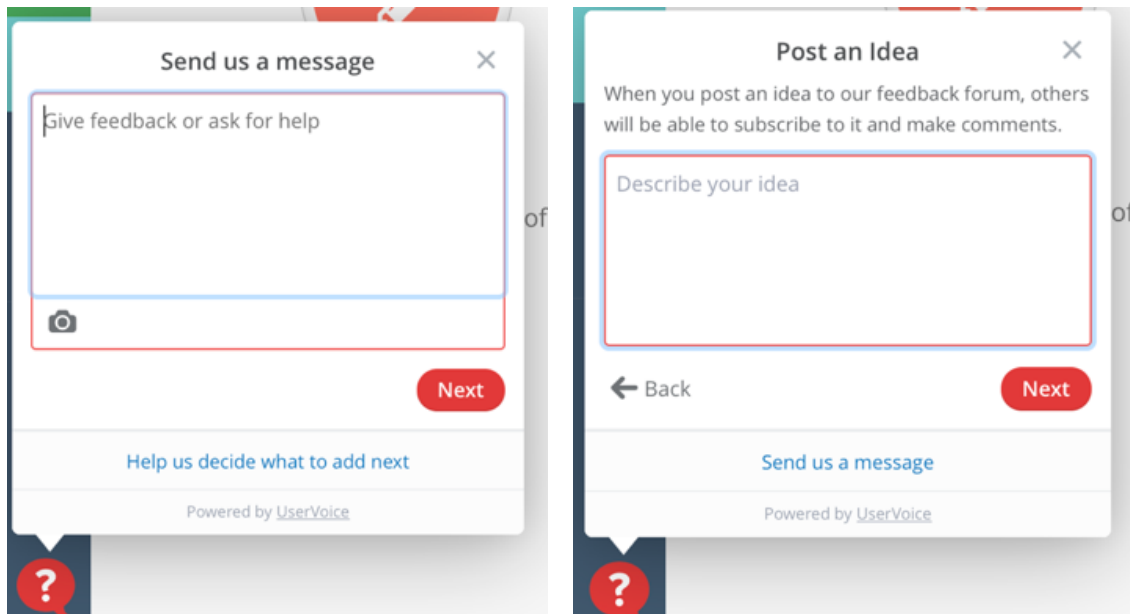
Figure 19. Product feedback software built into app. *Screenshot of bottom left corner of*

Guided app use. Between early January and April 2015, I embedded into the

teachers' classrooms once or twice a week for approximately two hours, observing and

interacting with the two participants as they used the application both in planning and

executing instruction. A detailed listing of those interactions can be found in a Data

Collection Timeline in Appendix B.

Data sources. The following data (listed in Table 2) were collected primarily

during guided app use. Examples of these sources are provided in Appendix C.

Field Notes. Classroom observations were guided by the observational protocol

designed to align with research questions.

Table 2
Phase II Data Sources

Source	Explanation	Total # of documents
Field Notes	Observations of classroom practices and app use	24
Classroom artifacts	Photos of teacher planning or instructional tools	22
Email exchanges	Emails between researcher and user	74
Interview transcript	Informal interviews conducted between unguided and guided app use; follow-up conversation	3
Think aloud	Screencast of teacher using app during planning	2
AdapDif user content	Surveys, notes, or grouping	45+
Simulated user issue videos	Screencasts illustrating an issue with application	7

Classroom artifacts. These data consist of photographs depicting teachers using

the application during instruction or teachers' artifacts that illustrate teachers'

differentiation practices.

Email exchanges. Email exchanges between the users and me were included as

another source to track how users interacted with the application.

Interview transcripts. An external transcriber translated the audio from two

interviews conducted in the period between unguided and guided use. The interview

protocol and excerpts from the transcripts are included in Appendix C. Informal phone

interviews were conducted in March of 2018 to follow up on teachers' lingering

reflections.

Think-alouds. I conducted two "think-alouds" with one of the two participants. During the first think-aloud, lasting 45 minutes, she built a survey on her computer while I took notes, and during the second she built groups using the survey data in the app, which was captured on screencast software (e.g., Silverback) and which I later transcribed. She talked about her choices and asked questions about how to use the app. I offered suggestions only when she struggled, or to circumvent a programming bug. The high school participant used the app more frequently and tended to "think aloud" as he used it, making a formal think-aloud unnecessary.

AdapDif user-created content. The participants used the application to record notes (i.e., with Quick Note), create and administer surveys (i.e., with Survey), and group students (i.e., with Group Mat). These data sources provided another lens on how teachers interacted with the application.

User issues. Silverback screen-casting software (Clearlift LTD) captured issues for the programmers in real time so they could visualize the problem. These recordings also served as data sources to capture app use. A screenshot from one video is included in Appendix C.

Data analysis. In order to systematically uncover meaning in the data relative to the research questions, I moved fluidly between descriptive and inductive processes (Marvasti, 2014). While I have explicated those processes below in a step-wise fashion, in truth, the analysis was iterative and recursive.

Coding. Maxwell and Miller (2008) delineate between relationships of similarity and contiguity in analyzing data—the former involves categorizing data while the latter

involves recognizing connections between data. Although I alternated between both types of analysis, I looked first for similarity-based relationships by creating units or segments of data (Coffey & Atkinson, 1996; Lincoln & Guba, 1985) through categorical coding. The coding framework needed to satisfy two seemingly opposing demands: (a) the practical concern that the data should be aligned to and shaped by the conceptual frameworks and the research questions, and (b) my ontological stance that "truth" is relative and constructed. Hence, I coded the data both deductively and inductively.

For both Phase I and Phase II data, I initially developed two sets of a priori codes. Yin (2002) suggests that case study research make use of "prior development of theoretical propositions to guide data collection and analysis," and so it follows that Phase I codes reflected the conceptual propositions of differentiation to guide this deductive coding strategy (e.g., practices—respectful tasks, teaching up, proactive planning, "knowing" students, flexible grouping; principles—high quality curriculum, ongoing assessment, safe and flexible learning environment, modified instruction, leading students/managing routines). I also established codes pertaining to general technology use in the classroom relative to the teacher and the student, as well as to the app itself (e.g., functionality, teacher use, and development ideas). For Phase II codes reflected the inner circle of the NCD model (e.g., opportunity identification, opportunity analysis idea generation and enrichment, idea selection, and concept definition). I defined each of these a priori codes and transferred them into a codebook in MAXQDA (Appendix D).

As I applied these codes to the data, new inductive codes emerged. These emergent codes included the following:

- *teacher codes* which capture the teacher's persona—his or her content

  knowledge, beliefs (i.e., about teaching or differentiation, expressed or

  implied), pain points (e.g., "test scores," "homework"), experience, goals,

  and style;

- *general practice codes* which identified teacher behaviors that capture their

  "typical" educational practice;

- *in vivo codes* which were phrases or concepts that the emerged from the

  teachers' own language, were repeated and were relevant to the research

  questions (i.e, "spend the time," "choice.")

Concurrent with this provisional coding, I engaged in memo writing. Memos acted as an

"intellectual workplace" to record emerging theories or possible connections between

data, questions to revisit, and to track and challenge my biases (Thornberg & Charmaz,

2014, p. 163).

After engaging in the initial coding and memoing, I swept the data again for a

final round of focused coding (Thornberg & Charmaz, 2014). Analysis at this point

became iterative – codes swelled with data, while others fell away. I loosely engaged in

the following procedure, for example, with Phase II data:

- I retrieved coded segments and their associated memos and pulled them into a

  summary grid (see Figure 20). In that grid I categorized and summarized

  data: results (i.e., "what happened"), action (i.e., what AdapDif might do),

  themes (i.e., emerging patterns for discussion), or literature (i.e., where I

  might need to circle back as some issue or question was raised). As I engaged

Figure 20. Summary grid illustrating focused coding (in the right column). *MAXQDA.*

in this process, I also reviewed the context of the code in the data and checked

to see whether I had missed something, adding a code if necessary (e.g.,

Seeing "This is about knowing students," did I also code "grouping"?).

- Pulling from these new categories (e.g., contiguity-based relationships), I

summarized how teachers interacted with the application in their classrooms

by combing through the summary tables for data that were coded

"results" (see Appendix E for an excerpt). I triangulated data (e.g., interviews

and observations) against the data in the app to verify their accuracy or refine

them (e.g., how often a user claimed to use a application).

- I returned to the bucket codes and compared them against the results

  summaries to see if any new relationships emerged.

I scrutinized Phase I data with similar vigor, although the process was more linear as data

fell into a narrative structure.

Trustworthiness

The design of this study stems from my constructivist paradigm, premised on a

relativist ontology that assumes a multiplicity of realities constructed interactively

between the investigator and the participants (Guba, 1994). This interpretivist

perspective also reflects my personal worldview, one in which objectivity is not a

plausible lens and reality is a subjective creation. Naturalistic data collection methods

used in this Capstone align neatly with this interpretivist approach; however, they are

laden with potential bias. While that burden is endemic to any single-researcher study, it

is exacerbated by my dual role as researcher and developer; hence, issues that may

bedevil a typical qualitative research are especially acute in this study in which the

researcher is so entwined with the phenomenon being scrutinized. The need to "validate"

qualitative data stems from a more positivist epistemology (e.g., Yin, 2002) than my own,

and so this section confronts the issues related to this bias and the measures incorporated

to attenuate them.

Membership. Although this is not ethnography—I neither aspire to social

commentary nor was I embedded deeply in the culture of the two classrooms I observed

—the extent of my membership in the setting must be examined to provide a fair

assessment of my credibility. Researchers have calibrated degrees of participation along

a continuum of involvement: non-peripheral, active, or complete membership (Ader &

Adler, 1987), or passive, moderate, active, or complete participation (Spradley, 1980).

My role in Phase II was that of a participant observer whose goal was to interfere in the

business of teaching as little as possible. I occasionally interacted with teachers and

students in order to facilitate the use of the application and ensure technical difficulties

did not impede instruction, and so my participation in that setting could be characterized

as peripheral or moderate. In Phase I, however, I generated the bulk the data, as co-

founder of AdapDif and as co-creator of the application. My membership in that phase of

the research was complete and immersive, and while that extremely *emic* perspective

provides invaluable insider knowledge, my singular lens also limited the scope of its

analysis and left it vulnerable to bias.

Literature in new product design (NPD) warns of pitfalls for stakeholders on the

design side of a project, and as a co-creator of the application I was at risk of falling into

those as well. For example, researchers (e.g., Cross, 2001) who examine design, suggest

that "designers become attached to their principal ideas, and they try to keep to them as

long as possible, no matter the cost" (p. 86). Further, research indicates that "managers

who initiate a project are less likely to perceive it is failing, are more committed to it, and

are more likely to continue funding it than managers who assume leadership after a

project is started (Schmidt & Calantone, 2002, p. 1). I certainly have biases toward the

success of the application. The threat of a sort of *observer-expectancy effect* hovered

over the data collection and analysis, as my cognitive biases might have had

subconscious influence on the users of the app, and *confirmation bias* (i.e., my

attachment to my own creation) might have lead me to interpret results with my own

hypothesis in mind. With those possibilities in clear view, I have incorporated the

following strategies to enhance the trustworthiness of the data:

Researcher-as-instrument. I am the sole instrument of data collection and

analysis, the lens through which the data are viewed and mediated. This fact warrants a

description of relevant aspects of myself—expectations, biases, assumptions—as well as

my relevant experiences.

As a graduate student, I have participated in courses focused on qualitative

inquiry, and I have applied them in multiple, IRB-approved research studies. In those

studies I practiced qualitative methods—observing teachers, conducting interviews, and

analyzing data—and, further, transformed that research into papers recognized by the

American Educational Research Association (AERA) and the National Association for

Gifted Children (NAGC). Both papers centered on teachers' implementation of

differentiation in their classroom. I have studied differentiation over the past seven years,

experience that includes evaluating districts on their implementation of differentiation,

providing professional development on its principles and practices for teachers across

grades, developing differentiated curriculum with both elementary and middle schools,

and instructing teachers in a graduate level course on differentiation.

While this experience arguably establishes my credibility in interpreting how

differentiation is applied in classrooms, it concurrently may also create an overly critical

or puritanical adherence to an idealized version. This potentially creates a problematic

blindspot as a developer/researcher in recognizing other solutions to responsive

instruction. My close relationship to the creator of the differentiation model (Tomlinson) also colors my interpretation of it, though clearly I would not dedicate years of study and found a company were I not a believer in its premise and promise.

My experience in gifted education also influences my view of curriculum and instruction. I earned a Master's degree in Gifted Education (with Carol Tomlinson as my advisor) and then taught 7th grade Language Arts in a magnet middle school for students identified as gifted by the district. The course I taught was similar to one taught by one of the pilot teachers, who taught an advanced language arts block, and so I have intimate knowledge of the domain and beliefs about how it should be taught.

Reflexivity. I also tempered my biases through reflexive practices. Peshkin (1988) contends that the researcher can earn her subjectivity by carefully monitoring herself throughout the research process and "disclos[ing] to [her] readers where the self and subject became joined" (p. 17). During Phase I data collection, I stayed mindful of my biases by inserting reflexive and analytical notes in my classroom observations as they occurred to me (e.g., "NOTE: I am feeling like she may 'give up' on the tool and want to facilitate its use since yesterday we had glitches with the Group Mat items not working. She had been trying to group based on questions she'd asked in the former survey, but it was not helpful because she'd asked questions where students could select more than one answer. It doesn't group smoothly on the mat"; analytical note, 2/12/16). Less immediate, but perhaps more thoughtful and consistent, were the notes I kept in a methodological journal (excerpted in Appendix F) through all coding phases (e.g., "It is admittedly slightly painful to hear, for example in the Think Aloud, when something

doesn't work on the app. The value of an actual recorded interaction is invaluable to

'keep me honest' in scrutinizing the process, and not just remembering the success or

excuses and, conversely, getting credit for those successes when she says things like "I

like this!" or "oohhh!"—journal entry). These reflexive practices allowed me to

"systematically seek out [my] own subjectivity" (Peshin, 1988, p. 17).

     Triangulation. Stake (2006) presents the following sweeping take on

triangulation: "The process of triangulation occurs throughout the fieldwork and analysis.

It means being redundant and skeptical in seeing, hearing, coding, analyzing, and writing.

It benefits from discussion with both critical insiders and outsiders. The exchanges

should be both routinized and spontaneous" (p. 77). His synopsis represents the critical

stance that I tried to maintain throughout the data analysis. Certainly, drawing data from

a variety of sources ensured that the study was robust and captured "the case under study

in its complexity and entirety" (Yazan, p. 142). But more importantly, I attempted to

emulate Stake's sense of skepticism about data, results, and inferences through memos,

analytical notes, and a methodological journal.

     Prolonged engagement. Lincoln and Guba (1981) suggest establishing a

relationship of trust between the investigator and subject. I visited both teachers'

classrooms at least twice per week for 4 months. While this frequency does not

approach the level engagement necessitated by an ethnography, the repeated visits and

communication about the app over time did create a level of trust between me and the

users. As mentioned in the researcher-as-instrument statement, I had also worked in the

classroom of the middle school teacher previously during a year-long internship in the

division. We developed a rapport during multiple interactions in which we designed

lessons together, one of which she asked me to deliver.

> ***Attenuation strategy: peer debriefing.*** A non-stakeholder in the research, an

individual with knowledge of the phenomena under study and of qualitative methodology

(e.g., having a PhD in Educational Technology and Curriculum) acted as a peer debriefer

as final drafts of the Capstone were refined. We reviewed the study beginning with the

research questions, moving through the two phases of research and their associated data

sets (which she briefly reviewed in MAXQDA). Given (2008) suggests a peer debriefer

ask clarifying questions, which she did regarding alignment and connectivity to big ideas

of technology and education. She also interrogated theories and helped clarify

interpretations.

Conclusion

> The methods applied in this study evince its complexity. Conceptually tricky, I

explored two separate but related phenomena: (a) the development of a solution to an

inherently fuzzy problem and (b) the success of the solution, as it manifested in a

product. This process required the systematic analysis of two sprawling, archival data

sets. My multiple roles—creator of the solution, overseer and observer of its

implementation, and analyst of the data—compounded the complexity of the task and

necessitated a hyper-awareness of my potential for bias. As a result, I triangulated data

whenever possible, engaged in reflexive practices, and debriefed with peers to enhance

the trustworthiness of the findings. In the next section, I present those findings in two

highly descriptive case studies corresponding to both phenomena.

CHAPTER TWO: FINDINGS

Findings correspond to the two phases of the research. The first section reflects

the application of the NCD (New Concept Development) lens to development and begins

to unpack the research question, "What can be learned in the development process of an

educational technology with a pedagogical mission?' Analysis in the second section

addressed the research question, "In what ways do teachers engage with an online tool

designed to support their attempts to differentiate instruction?"

Phase I: The Development Process Explored

This section analyzes of AdapDif's development against the NCD model. As

previously discussed in the Methods chapter (and shared again below in Figure 21), the
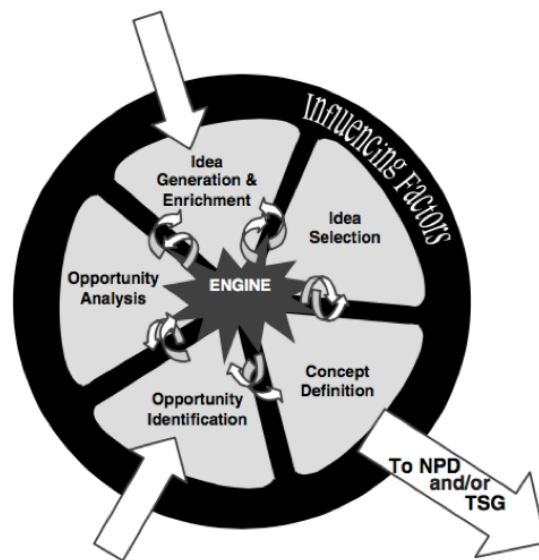

Figure 21. The NCD model. Reprinted from *Fuzzy front end: effective methods, tools, and techniques* (p. 8) P. A. Koen et al., 2002, New York: Wiley.

NCD Model proposes that new concepts develop in a circular flow, broken into iterative, step-wise elements, and encircled by an environment of influencing factors. AdapDif's data set is vast—collected over a two-and-a-half-year period—and, therefore, evokes an endless list of questions under the umbrella of "what can be learned." The influencing factors in the outer ring could, themselves, frame rich case studies in entrepreneurship, incubators, or start-up processes. For instance, when applied to AdapDif, one could ask: How were we hindered by the size of our team? (i.e., the company's organizational capabilities); How did defining the customer and/or competitor allude us? (i.e., customer and competitor influences); Who were our detractors? Who were our enablers? (i.e., the outside world's influences); To what extent were we hobbled by our technological limitations, our lack of "an algorithm?" (i.e., the depth and strength of enabling sciences and technology.) Even employing an alternate lens such as effectuation conjures a whole new line of inquiry around the educator as entrepreneur. The data exists to tell these stories in some detail.

To avoid the lure of these questions and more intentionally foreground education—specifically what, how and why AdapDif arrived at its online application solution—I analyzed Phase I data strictly according to the inner spoke of the model (as stated in the Methods section). This section culminates in an analysis of the data against the NCD model.

Opportunity identification/Opportunity analysis

AdapDif arrived at the iLab presumably with these first two steps behind us: 1) We had already identified our opportunity, and 2) we were unaware that we would need

Figure 22. Opening slide from Curry Cup competition presentation (11/13), recognizing an unmet customer need or previously undetected problem.

to assess or prove its worthiness. For instance, the opening slide of our Curry Cup presentation (Figure 22) identified the opportunity or "unmet customer need or previously undetected problem" (Koen etc al., 2002, p. 16). Our problem of practice was not undetected, and the "customer" need was certainly unmet. We further refined the opportunity description in our written application to the iLab:

The expectation of modified instruction based on students' needs, known as differentiated instruction, pervades K-12 education. Districts allocate significant funds for training on differentiation and purchasing products associated with it. Parents demand it. Teachers dedicate countless hours trying to accomplish it. Despite the massive focus on differentiation, its actual implementation eludes most teachers (Application for i.Lab Incubator, January 2013).

Judges' feedback from the UVA Cup presentation indicated we had lost the competition,

not on the merits of our concept, but on the deficiencies of our business plan (i.e.,

revenue model, "go-to-market" strategy, market analysis). While our presentation

included slides about the market as we understood it, we did not feel qualified—or

particularly driven—to win a business plan competition. Solving the problem excited us.

Unfortunately, the next spoke in the wheel, *opportunity analysis*, demanded an

assessment of the opportunity to confirm whether it is worth pursuing, and this process

echoed the iLab's programming and emphasis. This analysis step proved to be our first

moment of dissonance and comfort with it eluded us. As educators with both academic

and practical expertise in our respective domains, we did not feel we needed this

confirmation—we knew the opportunity existed to help teachers better understand and

implement differentiation. However, in business, worthiness is measured by the market

opportunity (i.e, market segment and size, growth rates, and market share of

competitors). In a large company, a team or division assembles to conduct this analysis

(i.e. of the market size, the major competitors in the market segment, and a determination

of what customer needs are not currently being met by those competitors). This team

would include, at a minimum, a person with marketing and research and development

experience, versus a start-up, in which the team *is* the team.

The iLab's focus on opportunity analysis is exemplified in requirement to

describe the *competitive landscape*—who the potential competitors were, how much of

the market they had, how they were not currently meeting customer needs. AdapDif's

Evernote files contains 38 notes with "competitor" in the title, a scattershot assortment of
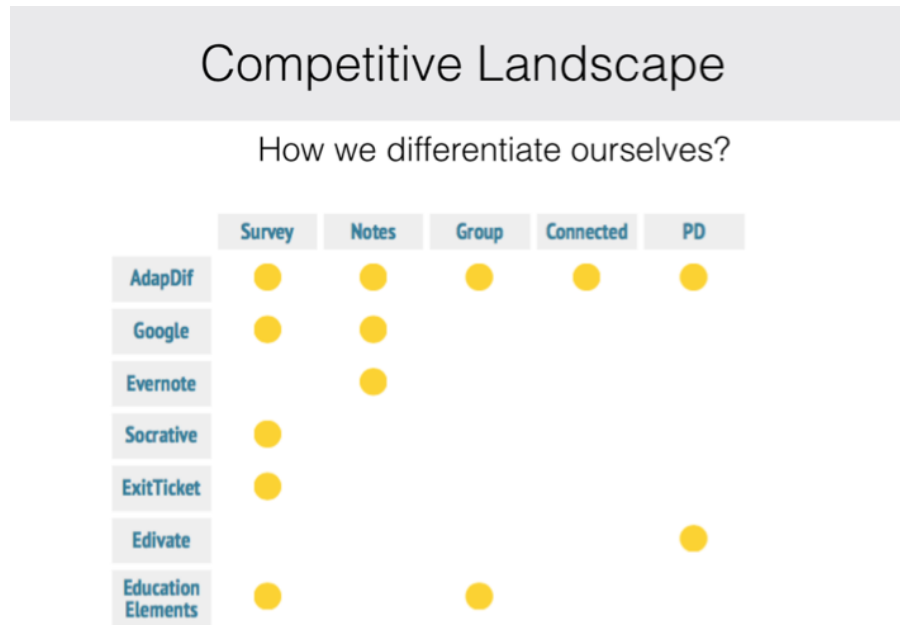
Figure 23. Presentation slide illustrating possible competitors for AdapDif.
From Gallant Presentation, May 2015.

tools for assessment, note-taking, planning, professional development. A slide from one

of our final pitches (Figure 23) illustrates the fragmented and complicated nature of our

perceived landscape: The top row lists AdapDif features, while the left column lists

companies with products that had a competitive feature.   For example, while Google

Classroom had not yet launched, teachers still used Google Forms to survey students or

Google Docs to take notes. A variety of products allowed teachers to survey students. In

a federal grant application, we explained the landscape thusly:

> Many growing and well-funded companies are developing products similar to the
> discrete components found in the AdapDif system. For example, companies such
> as Kickboard are gaining traction by building profiles of students and tracking
> behavior. Other applications work with student profile information generally use
> quantitative data (e.g. School Net) or use behavioral data related to discipline
> (e.g., Class Dojo, Kickboard). Many companies operating in the "adaptive"
> space (e.g., Knewton) attempt to individualize instruction for different profiles

> based on a hierarchy of skills. Still other technology solutions enable teachers to record observations or collect qualitative data but do not include any analysis nor the connection of data to instruction (e.g., Evernote for Schools). Finally, professional development companies (e.g., PD360, My Teaching Partner) have made forays into online teacher training (SBIR Phase I Proposal, Google Docs, 12/13, p.12).

We were only able to identify companies that focused on isolated elements of differentiation. We envisioned a comprehensive solution with interconnected parts that we did not see reflected in the market. We were unable to convincingly explain that our (eventual) solution would contain a combination of features, some found in other products, others that did not exit at all: Investors, in turn, could not envision a product without a direct competitor, and the competitive landscape as we described it appeared overrun and fragmented.

The demand that we position ourselves in the market pervades the data (i.e., notes taken during guest speakers, email advice from parade of entrepreneurs, and perpetual "pitch" preparation). This perplexing puzzle pulled focus from our more pressing goal, that of translating what we speculated to be the causes of teachers' struggle with differentiation to an online solution. The tension between business and conceptual concerns proved prophetic, and it persisted throughout the development process.

Idea generation and enrichment/Idea selection.

Theoretically, the NCD model views these two steps separately: *Idea generation* births and develops an idea through many iterations, and, according to the model, includes direct contact with customers; *idea selection* involves choosing which idea to pursue according to its business value. In practice, or at least in AdapDif's practice, it is

difficult partition them as they were so interwoven. Idea generation proved fruitful, but

short-lived, while idea selection urgent and arduous.

     Idea generation. Unlike the drudgery of opportunity analysis, AdapDif's

brainstorming process was a joyous and intellectually cacophonous endeavor. Ideas

bounced from sketches, to whiteboards, to wireframes and back again, all in service of

transforming Tomlinson's model (2014) into a tangible, online system. In this way, we

were in step with the description of the phase of the NCD model:

> Idea generation is evolutionary. Ideas are built up, torn down, combined,
> reshaped, modified, and upgraded. An idea may go through many iterations and
> changes as it is examined, studied, discussed, and developed in conjunction with
> other elements of the NCD model.   Ideas may be generated by anyone with a
> passion for a particular idea, problem, need, or situation (Koen et al, 2002, p. 19).

As that person of passion, I generated an almost endless stream of ideas, collected in

voice memos, emails to my co-founder and programmer, photos of post-it notes, Google

Docs, and whiteboard sketches. Caner quickly tried to impose order by insisting we

record all brainstorming in Evernote (the bulk of which constituted data for this phase of

the research).

     Guided by the iLab emphasis on the market and the purported needs of the

customer, our early ideas served the teachers' propensity for tools. Initial ideas ranged

from applets (i.e., small software programs that support a larger application program) to

blueprints for more substantial app features. Our early brainstorming started by

transforming familiar differentiation strategies into digital tools and creative ways to get

informal student data into the system, For example, we sought ways to visually "know"

students, one idea being an "All About Me" glyph tool. Figure 24 illustrates Caner's
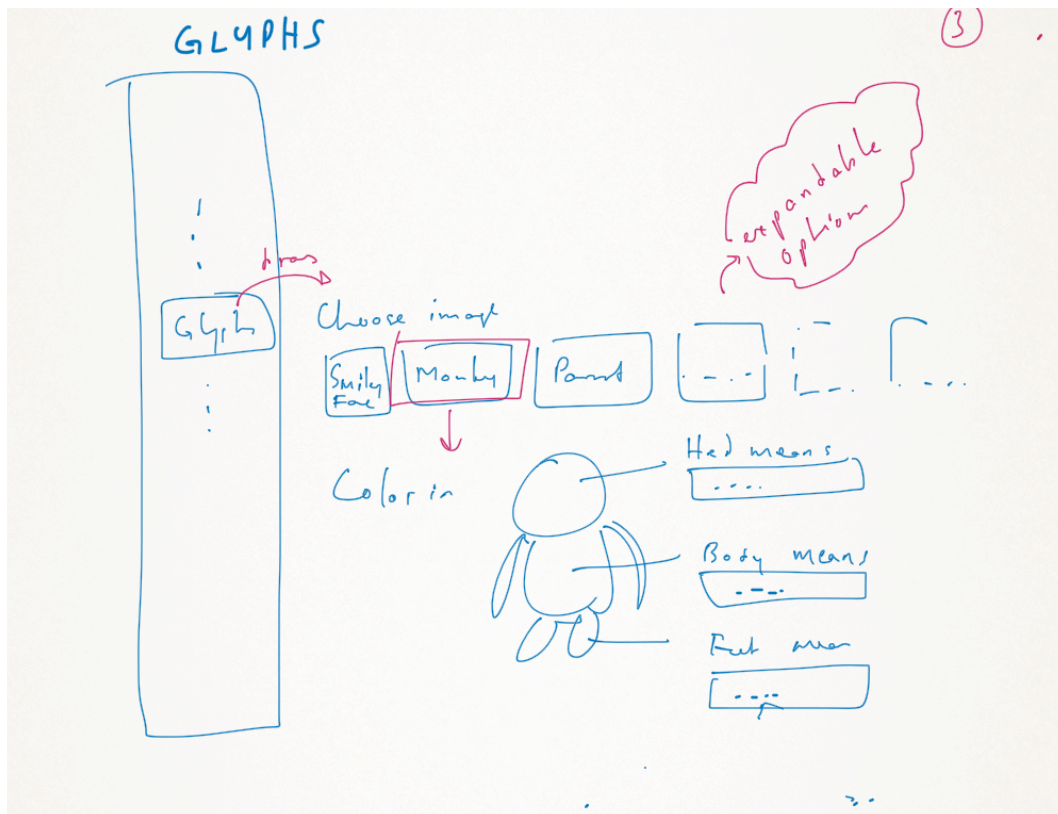
Figure 24. "Glyphs." A idea for building interactive, visual student glyphs to collect data for student profiles (i.e., the head means _____; the body means _____; feet mean _____). From Notes for Patentability. Evernote, 5/17/13.

attempt to sketch the glyph as programable applet: A student would select an avatar to

represent him or her (e.g, a monkey) and digitally color body parts to represent different

attributes. We also considered ways to maximize the power of these tools to visually

provide insight for the teachers about their data. With the glyph applet, for instance, we

wondered if the completeness of the avatar could indicate how much data the system has

about the student. Elaborating in an email, I explained, "I am picturing using layers in

photoshop or a series of filters where the image goes from a line drawing to greyscale to

full face. Just a brainstorm, not imperative. For later" (personal communication,
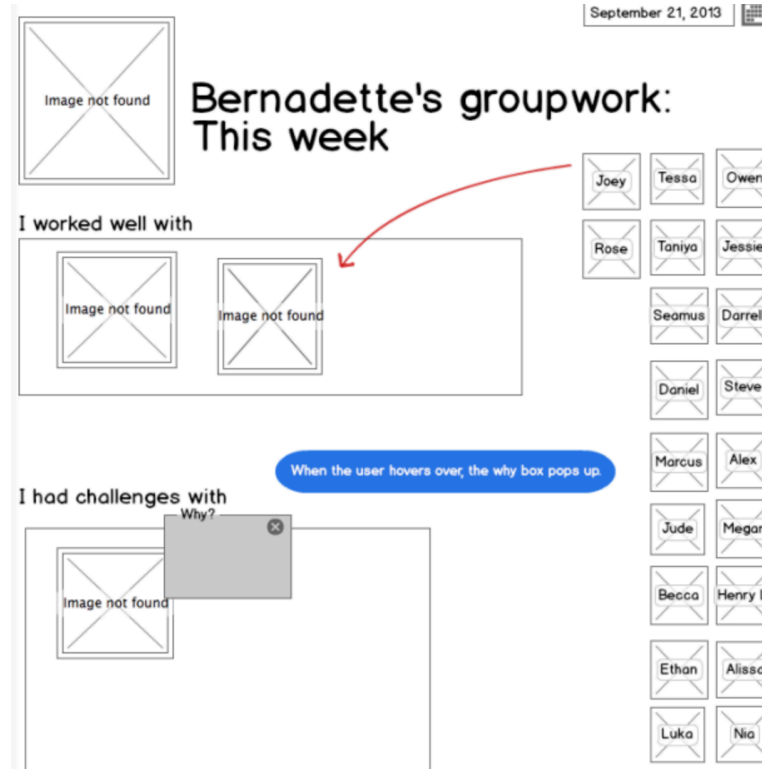
Figure 25. Design for a student-facing applet in which students
could enter data into the system. Balsamiq Wireframes, 7/5/13.

5/30/13). We generated many ideas in this phase, and "later" never came for the majority

of them as iLab processes demanded we move swiftly to product development (which

will be explored in the next step).

As our ideas began to stockpile, Caner introduced wireframing (i.e., the process of

building blueprints of a webpage) to visualize the plausibility (and programmability) of

an idea. These visual schematics display the potential lay-out of content and functions on

a webpage. The wireframe in Figure 25, for example, blueprints an applet in which

students could reflect on the dynamics of their group work while concurrently providing

the system with data about interactions between students. We also contemplated ways to
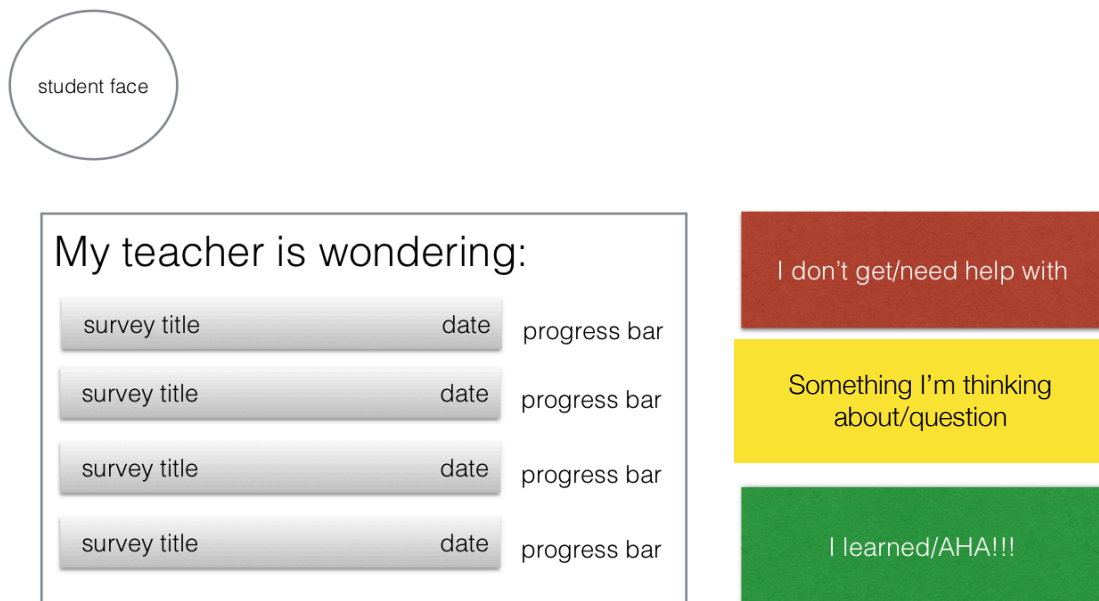
Figure 26. Wireframe design for a student dashboard with option for student to enter data. Evernote, 5/22/15.

lessen the burden on the teacher to collect data and, instead, allow students to input data

into the system. One such example is illustrated in a basic wireframe (Figure 26) for a

student dashboard on which a student could click a colored button as a windshield check

(i.e., red indicates "I don't get/I need help with," yellow indicates "something I am

thinking about," and green indicates "I learned").

Analysis of the wireframes also indicates that we were already experimenting

with ways to build the professional development (PD) layer early in the development

process. For example, we constructed a wireframe (Figure 27) in the middle of the

Accelerator that included an "Applied Professional Development" column. It illustrates

our proposition that the app could suggest questions according to a teacher's inputs. For

example, if a teacher were to tag a survey question as "readiness," the system might ask,
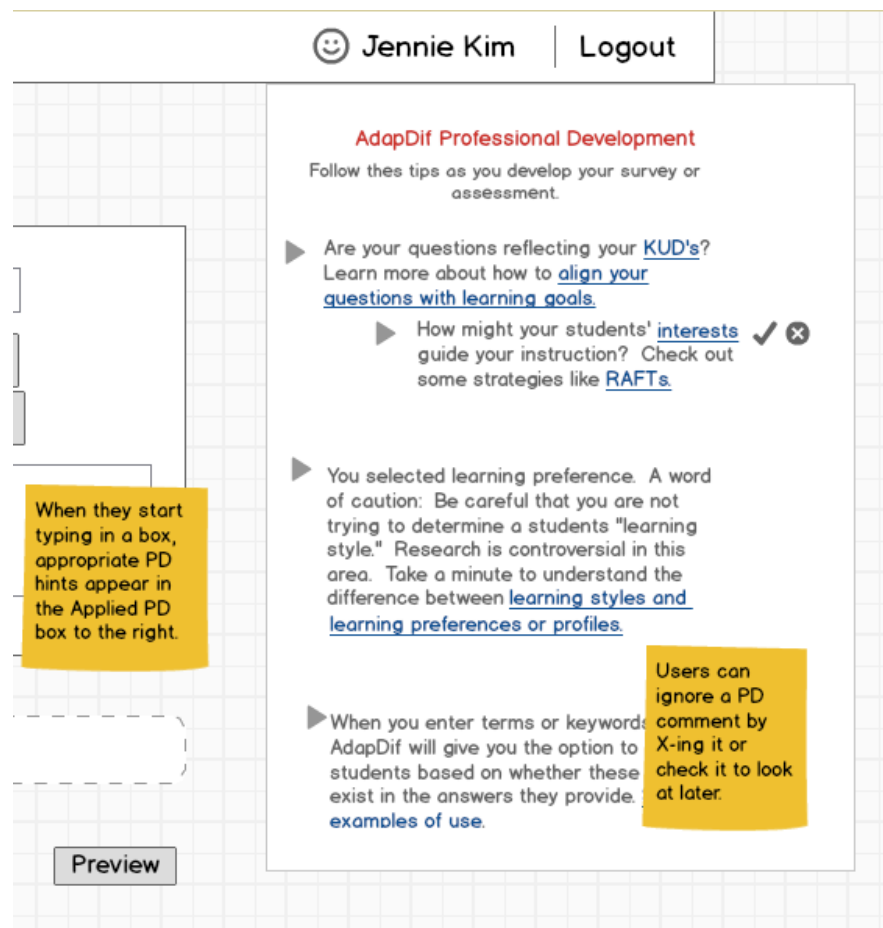
Figure 27. Wireframe for survey tool with close-up on PD function
with reflective questions link to teacher interactions. Balsamiq
Wireframes, 7/16/13.

"Are your questions reflecting your KUDs? {i.e., learning goals]" and link teachers to a

related video on learning goals and alignment.

We could have happily spent the length of the Accelerator generating ideas. We

had barely touched on crucial elements that hold the model to together, for example,

mindset (i.e., an idea for a rotating banner across the teacher dashboard with quotes and

reflective questions to inspire thinking; a survey tag for "growth" to prompt teachers to

revisit items over time) or curriculum (i.e., providing scaffolded examples of how to use

essential questions with all students). We had also tentatively begun to consider how the

system (what we informally called the "AdapDif Brain") could find useful patterns in the

users' behavior. For example, a teacher testing the app commented that she was taking

Quick Notes about one student far more frequently than others. In a note titled, "The

AdapDif brain: Early Patterns," I wrote,

> [W]e need a reminder from the app that points this out. I think this can be an
> early "AdapDif brain" reminder: "You have taken X notes on (most) and Y notes
> on (least)." "Here are the top 3 students you have noticed: x with 10, y with 8 z
> with 7." "Here are the bottom 3."   "You haven't asked about student X in 2
> weeks" (Evernote, 2/16/14).

While we would have preferred to stay in this unfettered ideation phase longer, the iLab

halted this idea gestation period with the demand that we build something tangible.

Idea selection. Although we culled and revised ideas along the way, idea

selection became more urgent when the director of the iLab insisted we produce an MVP

by the end of the summer. Meeting notes indicate she delivered this message to us three

weeks into the Incubator, as early as June 21, 2013: "Get highest quality MVP done:

Validation season in the fall." To facilitate and, perhaps, accelerate this process, she

paired us with a new entrepreneur/advisor to prod us toward that goal.

While most influencing factors (i.e., from the outer circle of the NPD model)

generally did not infiltrate our development, the process espoused by this advisor did.

The assigned advisor had written a book about starting a tech business (Cowan, 2012),

based on a development path that promised to move a start-up from a problem to a tech

solution. Rooted in a hodgepodge of adaptive development methodologies (e.g., *agile*

and *lean),* his proposed model, *Venture Design,* required the validation of tech start-ups to

VENTURE DESIGN PROCESS

Figure 28. Venture Design Process, a pathway from problem to a "tech" solution embedding adaptive development methodologies.   Cowen (2018) retrieved from https://www.alexandercowan.com/venture-design/.

reinforce its legitimacy. As a result, in the middle of the Accelerator (and our

development process), we engaged in a series of Skype calls with him from his Silicon

Valley home during which he encouraged us to follow each step in the pathway illustrated

in Figure 28. While we spent a few weeks trying to reconcile where we were in our

development process with his model, data suggests we vigorously attempted only two

steps: creating *personas* and *user stories.* Ed tech researchers (Recker et al., 2015)

characterize personas as

> archetypes of the people who will be using the product or service. The objective
> of creating user personas is to gain a deeper understanding of who the users are—
> most importantly their contexts, motivations, goals, problems, and needs. The
> best user personas are often created through observing the behavior of potential
> users and/or engaging with them directly via interviews or surveys. (p. 160).

User stories characterize the persona as someone who wants to do something so they can

derive a benefit. They are designed to be brief enough to fit on a sticky note, and follow

a standard format: As a [type of user], I want to [goal] so that I can [objective]. A user

story defines the functionality of a product, or "what it would need to do in order to help

the users accomplish their goals" (Recker et al., 2015, p. 160).

This advisor's recommendations mirrored basic practices used by UX (i.e., user

experience) software designers who are typically concerned with enhancing the usability

and satisfaction of the product. This process reflected a software development paradigm

that resonated with Caner, as it backward-mapped from an imagined user's perceived

need to a buildable feature. He identified with the fact that a user story and a use case

could be logically transformed into something programmable. As a result, Caner

dutifully downloaded the templates to our Google Drive, read the advisor's book, and

even wrote his own version of a persona based on the solutions we had been planning

(Appendix G). Conversely, I bristled at what I interpreted to be more busy work

retarding the idea generation and selection process. In truth, I had been bombarding

Caner with new ideas, and he had dutifully been translating them into "sprints"—or

development to-do lists—which we would reprioritize in almost daily meetings

(Appendix H).

Despite my protestations that personas were contrived and arbitrary, I, too,

eventually capitulated and created a series of them (see Appendix I for representative

list). I also included Venture Design's requisite charts that further distilled the teachers

into what they "think-see-feel-do." Two examples of my personas follow: The first is a

composite character based on my years working with teachers, and the second is a

fictionalized version using real quotes and concerns from teachers attending a conference

on differentiation.

> **Example One.** Jenny is a teacher "lifer." She has been an elementary teacher for
> over 20 years and still loves getting new batches of kids each year. When school is
> out, her garage fills with the bins of books and materials she has accrued over the
> years. (Like most teachers, she has a hard time throwing things out.) Similarly,
> she has collected and developed strategies and lessons that work for her but is still
> open to new ideas and can usually take one idea from a good teacher training and
> adapt it to what she already does in the classroom. She has been teaching 3rd
> grade for the last 6 years but has taught everything from kindergarten to 5th. She
> has seen educational trends come and go and takes them all with a grain of salt,
> while maintaining a positive attitude. She has a strong influence on what happens
> in curriculum planning and in communication with the principal and at the district
> level.

Example 1: Jenny	
Thinks	She thinks she already differentiates, for example, by providing choices for students when they do projects.
Sees	She sees students more as "types" than as individuals: "3rd graders love this" or "my gifted kids can do this."
Feels	She feels very confident in her ability to teach and feels she doesn't really need to change what she does fundamentally. She tolerates technology and secretly feels she has been doing just fine for this many years that she doesn't need to explore it too much.
Does	She gives students choices in their projects at the end of the year, something she's done for many years in which they design their own model of an ecosystem. She also groups students in reading groups leveled loosely as "below," "on" and "advanced." While the district insists teachers do benchmark testing to determine reading levels 3 times a year, Judy rarely moves the kids around, and so they tend to stay in the same groups. Still, she manages to get almost all of them to pass the state assessments. She uses her smartboard like a digital chalkboard projecting word documents or websites, not maximizing its use.

Figure 29. What a user thinks-sees-feels-does, 6/27/14, Google Drive

Example Two. Becky is a 20+ year veteran, K-5 teacher who is a
"departmentalized" math teacher, meaning that she teaches math for her grade
level (80+ students.) She "really needs a streamlined way to meet student needs."
She expects to be treated as a professional and "feels it is important for me to learn
from a professional." She is skeptical of "fluff" such as some of the learning styles
workshops she's been forced to attend and is interested in "tested and practical
strategies, and ways to manage a diverse classroom in an efficient and effective
manner and be able to track the results of my teaching."

Example 2: Becky	
Thinks	"I feel that in public education teachers are faced with such an array of learners with different needs, styles, and levels of support outside of school." She thinks differentiation is possible and necessary.
Sees	She sees 80 kids a day, much like a middle school teacher.
Feels	"Although I have been in education now for over 20 years, I feel I am never able to meet the needs of all the students in my charge to the degree they need especially at the two ends of the spectrum."
Does	"I try different things every year with varying degrees of success." She attends differentiation training for a week in the summer. In order to attend to different levels of readiness, she often puts students on a computer program that adapts to their skill level. She does this often with her 2 or 3 advanced students.
PAIN POINTS	"How to assess student needs How to tailor learning experiences to individual needs How to track progress Managing documentation"

Figure 30. What a user thinks-sees-feels-does, 6/27/14, Google Drive

Still frustrated with the reductiveness of the task, I created a table (see Figure 31)

to the top of the persona document to illustrate the variables one could plausibly

incorporate into an educator persona. The variations seemed endless and creating them

an overwhelming and time-consuming exercise.

GRADES taught	TEACHING experience	DIFFERENTIATON understanding	TECH comfort	EDUCATOR role	SCHOOL/ DISTRICT type
Elementary	Novice	Well-trained, buy-in	High tech usage, early adopter	Classroom teacher	Public • Affluent
Middle	5-yr +	Some exposure, some buy-in, some misconceptions		Specialist	• Urban • Rural
High School	Veteran		Daily user, but not risk-taking	Coordinator	• Title 1 Charter/Private
		No buy-in, misconceptions		Administrator	
		No buy-in, rejects premise	Minimal tech usage		
			Tech-phobic		

Figure 31. Variables to consider in creating a teacher persona, 6/27/14, Google Drive

AdapDif exited these ideation stages prematurely. As is common in any early brainstorming process, we initially superficially addressed the problem. For example, our first ideas merely transferred differentiation strategies to an interactive, online format (e.g., interactive glyphs, interactive templates for RAFTs or learning contracts, digitized "me" graphs). As our thinking evolved, we began to look at the harder problem of helping teachers understand gathering data and transforming it into instruction (i.e., AdapDif's instructional line of logic). Caner had been actively inserting processes that systematized these phases, and so Venture Design offered him support in that pursuit. The iLab demanded that we rush to complete an MVP, while the Venture Design process asked us to backtrack and slow down, create a series of fictional customers, and map their daily challenges to a set of features.

Concept definition

A company crosses the finish line in the NCD model at concept definition: "In order to pass through the gate, the innovator must make a compelling case for investment

in the business or technology proposition" (Koen et al., 2002, p. 22). When the NCD

process is embedded in a large company, a team would submit the proposition—a

technology supported by business imperatives—to a gatekeeper who would then evaluate

how compelling the investment appears. For the start-up, potential investors make a

similar decision. The compelling case manifests as "the pitch"—a quick, persuasive

burst that summaries what pressing problem your product or team uniquely solves (for a

large and hungry enough market to make the investor money). This compelling summary

eluded us, as our message morphed with how we planned to solve the problem of

practice. Table 3 illustrates the iterations our pitch to various audiences.

At the iLab, concept definition was not the "finish line," but a weekly pursuit.

During the eight-week summer Accelerator, companies continually refined their "pitch"

and practiced it weekly. While AdapDif was still firmly entrenched in the idea

generation/selection phases—in our minds "incubating" a solution to an educational

problem—we were concurrently expected to sell that evolving idea to an investor. In the

11 months between the end of the Accelerator (August 2013) and user testing (July

2014), we spent the bulk of our time refining the MVP to perform reliably enough to test

in a classroom. We also, however, conducted an (unsuccessful) grant-based search for

funding, even submitting two proposals to the Small Business Innovation Research

Program (SBIR), one through the National Science Foundation (NSF), and still another

through the Institute of Education Sciences (IES).

Feedback from grant reviewers reflected the same dissonance we experienced in

the iLab. One reviewer opined, "The application creates a unique and much-needed

Table 3
Iterations of AdapDif's "pitch"

Date	Purpose/source	ADAPDIF is
11/2/12	Curry Cup Proposal	a solution to the teacher's problem of trying to "know" and modify instruction for so many students with so little time
		a machine-learning tool that collects data from teachers, applies a set of rules and provides options for teachers to use in her class.
3/16/13	ILab company summary	a web and mobile application that supports teachers by using cutting edge technology so that they can spend more time doing what no algorithm can do: interacting with and inspiring their students.
11/2013	NSF/SBIR Program Phase I Solicitation FY-2014	a cloud-based application that connects pedagogy to practice.
		a cloud-based application for K-12 teachers and administrators in which users select tools and training that applies directly to their classroom needs.
		"interconnected" and will move teachers through the process of differentiation from their point-of-entry.
3/ 2014	IES/SBIR Phase I Proposal	an innovative cloud-based tool for K-12 teachers that not only helps them better know and understand their students, but also guides their instructional planning based on ongoing student profile that they build over time.
		not a one-time intervention but rather a companion tool for teachers to use for any of their classes or in any instructional
April 2015	"The Deck"	"an intuitive interface that … creates an flow of information between teacher and student that is not top-down, but … learns and aggregates the individual behavior of instructors and student … guides teachers on what to do with the data, how to make it actionable …is flexible and scales so that it informs not only the system of the classroom but ecosystem

training tool," and "the team is extremely well-qualified to execute all deliverables." Yet

another review stated, "It is not clear why it is going to take 1 1/2 to 2 years to get this

product to market when a 6-month phase will result in a saleable product"and that

"competitive analysis is superficial and competitive differentiation is not well explained;

market analysis is poor. Segmentation is non-existent and penetration numbers are

idealistic at best." Still, another reviewer summarized the position of an investor: "not

high-risk, high-reward" (Proposal Review, NSF, 4/13/14). In fact, feedback accurately

captured our own inability to reconcile what we thought we were doing (i.e., "creating a

unique and much-needed training tool"(Proposal Review, NSF, April 13, 2014)) with and

what we were being asked to do (i.e, translate our vision into a convincing business plan).

When the grueling grant process revealed similar short-comings in our business

argument, we decided to return to the idea of seeking angel investment. To improve our

pitch, we met with a new advisor who had expertise in branding, an entrepreneurial track

record, and experience developing educational software. Over a series of meetings, we

proudly demonstrated the prototype we had agonized over and rushed to fruition

(2/11/15, 3/12/15, 3/24/15, Evernote). We also expressed the dissonance that had

culminated over two years: How do we make sense of fast-fail philosophy? What if we

do not want to "pivot?" What should our revenue model be? How do we position

ourselves in the market?

After a great deal of patient listening and a few clarifying questions, the new

advisor finally offered, "What you have shown me is a neutral platform. You have been

asking questions about features, price, business models, revenue models, customer type,

investors—ok. But those are all questions of *what*. I want to know your *why*. What is

your why?" (Evernote, 3/24/15).

Unclear about his meaning, we asked if the "why" is something a start-up

articulates to better sell its idea or to better understand what to feature the user wants. He

explained, "The why is the reason you get out of bed every day to do the thing you are

going to do" (Evernote, 3/24/15). In an informal conversation with me years later

(personal communication, March, 2018), he reflected on these these initial meetings and

recalled,

> You guys were telling me about investors and investments, and I said, 'I haven't
> heard you mention teachers or students once in three meetings.' Caner pointed
> out that you hadn't talked about them for six months, and when you started, that's
> all you talked about—teachers and students.bbI think the problem you want to
> solve is helping society, because society is better if education is better, and
> education is better if teachers better meet the needs of students, and software can
> help teachers do that. Your software can help teachers do that. The why,
> AdapDif's why, is because you want to change the world by helping teachers
> through differentiation to help students (personal communication, Evernote,
> 3/5/18, Evernote).

In fact, we had drifted so far from our why thatwe had lost the ability to articulate it. Our

why had been the impetus for creating AdapDif, despite the rigorous demands of our

doctoral programs. Still, the data contain no trace of it; instead, the meeting notes and

planning documents overwhelmingly focus on the "what" and the "how."

I chose the inner circle of the NCD model as a lens on Phase I data because it

seemingly structured the messy process of generating, discarding, accepting, and

ultimately transforming ideas into a tangible product. Each step in the model includes a

phrase that indicates the development process it frames is not purely creative, but is

informed by business demands: Opportunities are identified and analyzed in terms of

business goals, and ideas are selected to "achieve the most business value," and the end

goal is a "compelling case for investment in the business or technology proposition."

While I thought I could perhaps dismiss or deemphasize the business language in the

model, it ultimately helped clarify why we felt such discordance during development.

Theme I: Misalignment of Purpose and Process

My first research question posits, "What can be learned in the development

process of an educational technology with a pedagogical mission?" Two themes emerge

as a result of this question—one explicated here and the other at the end of the Findings

chapter. The first theme to surface was also, perhaps, the simplest and most obvious:

Constantly working at cross-purposes with the iLab generated a dissonance that crept

into our development process and impacted the app we ultimately created. While we had

been trying to solve an educational problem of practice, the iLab tried to prepare us for

investors in search of a high-risk investment with a high-return. AdapDif's goal was to to

build a research-based software with a pedagogical mission; the needs of the students and

teachers are incongruous with those of a start-up investor. As much as we struggled to

follow iLab directives, they slowly infiltrated and corrupted our development process.

The misalignment of our respective goals can be captured in business processes that

exemplify moments of dissonance that impacted the solution operationalized in our app.

Delineating the competitive landscape. Our first confusion was conflating an

educational problem of practice with an opportunity in the market. This schism became

apparent as investors sought to understand AdapDif's problem and solution relative to

pre-existing products with which they were already familiar and perceived to be

successful (e.g., Khan Academy). Because potential investors must justify their

investment, they need to believe a competitive differentiator exits between the start-up

and other companies addressing the problem. This is not an unreasonable demand for

someone taking a large monetary risk. In trying to satisfy this demand, however,

AdapDif identified a wide variety of companies that claim to address a piece of the

differentiation puzzle. This seemingly diffuse landscape seemed daunting and our place

in it unclear. As investors pushed us for an identity, we searched for pithy explanations:

Were were Khan Academy + Evernote + Google Forms? Were we the Teaching Channel

with tools? The more we tired to prematurely situate a theoretical solution and prove its

worth relative to pre-exiting products, the more fragmented our thinking became. This

fixation on features and functions influenced the resultant "neutral" platform with a

limited set of discrete tools.

Rush to a Minimum Viable Product. We might have reconstituted our thinking

into a more holistic solution given time; however, the demand that we produce an MVP

by the end of the summer Accelerator exacerbated our splintered line of thought. Our

initial plans and product descriptions outline a complex and sophisticated system that

would use tools as a means to an end— as conduit for improved teacher practices.

AdapDif needed more time to thoughtfully address the complexity of differentiation and

comprehensively operationalize our Connected Differentiation Model through research

and testing.

Investors in software startups insist that the software show revenue and profit

quickly, and, therefore, they steer company actions toward an MVP to be entered into the

marketplace where it can be tested against revenue goals. The iLab endorsed this start-up

dogma, understandably, because their goal was to prepare ventures for early stage

investment. However, AdapDif's MVP was not "sellable" in its simple form, despite

some advisors suggesting we just "throw it in the marketplace to see how it

does" (Evernote, 5/15). AdapDif needed to engage in methodical process that slowly

resulted in a product whose value increased over time, as its functional complexity began

to benefit its users. This process was at odds with *agile* processes like *fail fast, build and

burn,* and *pivoting* that promote quick, drastic shifts when instant results are not

evidenced.

Venture Design detour. A software entrepreneur shepherded us through the idea

selection process, based on UX concepts: personas, user story, use cases. While this

process seemed valuable when evaluating the usability of features, it pulled AdapDif

farther from the big picture solution we needed to contemplate. The process of contriving

personas was particularly vexing because it seemed to complicate an already complex

problem.

The process could also be useful to someone operating outside their domain—

someone with entrepreneurial aspirations in search of a product and market. The

AdapDif's team had accrued knowledge of potential users from over a decade experience

in the field and our systematic study of education as doctoral students. As educators

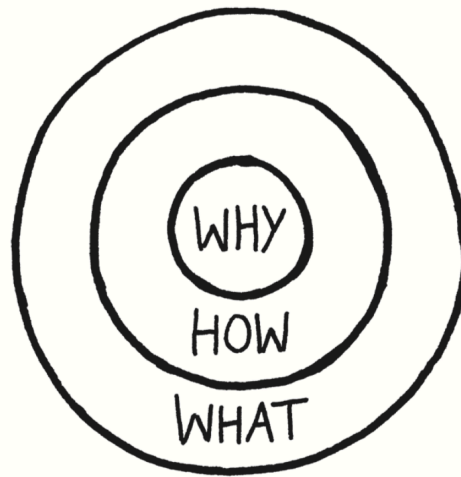ourselves, the process felt reductive, dehumanizing even—shrinking a teacher's entire

Figure 32. The Golden Circle explains that inspirational leaders think, act and communicate from the inside out, from their "why." Reprinted from Sinek, S., Mead, D., & Docker, P. (2017). *Find Your why: A Practical Guide for Discovering Purpose for You and Your Team*. Penguin.

being to a to a post-it note. Venture Design process offers "techniques for decomposing your idea into a set of UI components" (Cowan, 2014). These techniques might have helped us were we clearer on the "idea" and had we been ready to think about it in terms of components. In being asked to think in this way, we leaned toward a siloed solution.

Refining of the pitch. A pitch communicates to a potential investor that an idea uniquely solves a problem and will lead to large return on an investment. While the AdapDif team believed we were creating something that was clearly valuable to teachers and students, it was less obviously valuable to an investor. The more the iLab trained us to convey the latter, the further we moved from our "why." Sinek and his co-authors (2017) visualize this as a set of concentric circles, with the why at the center, illustrated in Figure 32. He characterizes its importance in the following way:

> Every organization—and every person's career—operates on three levels …
> What we do, how we do it, and why we do it. We all know what we do: the
> products we sell, the services we provide or the jobs we do. Some of us know
> how we do it: the things that we think make us different or stand out from the
> crowd. But very few of us can clearly articulate why we do what we do. The
> pitch is not based on facts and figures, features and benefits. Those things have
> value but not first. Leading with WHY has a deeper, more emotional and
> ultimately more influential value … We're talking about who our company is and
> what we stand for (Sinek et al, 2017, pp. 12-15).

As Table 3 illustrated, our pitch stemmed from our "what" or our "how," and we

presented ourselves as:

- a machine learning tool that collects data and applies rules,

- a web and mobile application that supports teachers,

- a cloud-based application that connects pedagogy to practice,

- an innovative cloud-based tool,

- not a one-time intervention but rather a companion tool,

- an intuitive interface that creates an flow of information, learns and

  aggregates the individual behavior, guides teachers on what to do with the

  data/how to make it actionable, flexible and scales.

The fact that we rarely made distinctions between AdapDif as the name of our company

and AdapDif as the name of our product reinforces our inability to distinguish between

what we were building and who we were. In short, AdapDif—the team, the concept—

aligned with the same beliefs from which differentiation spring: equity-of-access to

meaningful instruction and the elevated role of teachers to "grow in the ability to dignify

human potential" (Tomlinson, 2014, p. 36). In trying to manifest this, we locked

ourselves into an iterative what-how feedback loop, colored by the perceived needs of an

investor.

Phase I Conclusion

In the introduction to this Capstone, I presented AdapDif's backstory as an

orderly evolution of ideas, when the truth was far less disciplined and more haphazard.

The NCD lens similarly provides order to a development plan that lived largely in our

heads, articulated only when outside forces demanded it (e.g., a grant application, a pitch

competition, a presentation to a potential investor).

There were useful lessons to be learned from AdapDif's time in the iLab that

would have been more useful had we been further along as a venture or had we better

understood the goal of a start-up accelerator/incubator. Our view of incubation was to

examine a problem deeply and translate that study into a highly informed and thoughtful

solution. We believed that if our solution were compelling enough for the greater good

(and attracted enough potential users), we could find an investment to bring that solution

into being. Our focus on the *what* and the *how* of AdapDif left us unable to convincingly

pitch from our *why*.

By the end of the full year at the Incubator, followed by another year of residency,

we had managed to follow their processes to build an MVP that was now in the hands of

teachers. The next section will reveal whether we built the right thing.

Phase II: Testing the app in the classroom

In the last section I traced a process (how AdapDif moved from a theory about

how to solve a problem of practice to a testable "solution" to that problem), which I then

synthesized in a culminating theme. While Phase I necessitated a first-person narrative,

my second research question (e.g., "In what ways do teachers engage with a an online

tool designed to support their attempts to differentiate instruction?") suggested a shift to a

more objective, almost 3rd person perspective. While I am the narrator and still

occasionally part of the story, I approached this phase as a researcher presenting and

comparing two individual cases: That of Mr. Grayson (a high school social studies

teacher) and Mrs. Morrison (a 6th grade ELA teacher) as they test the AdapDif app over a

single school year. In sharing and discussing the findings of Phase II, I first detail a

picture of both teachers' style and instructional contexts, then describe and analyze their

app use, and—last—conclude with two synthesized themes that emerged from the

analysis.

Participants' style and context

I first present each case separately, setting the stage by describing each teacher's

general teaching style, followed by instructional snapshots of his or her classroom

contexts. I then provide a descriptive account of their app use and conclude with two,

final themes gleaned from the analysis.

Case #1: Mr. Grayson. A flexible and experienced teacher, Mr. Grayson created

a laid-back classroom environment that reflected his temperament. His 12th grade

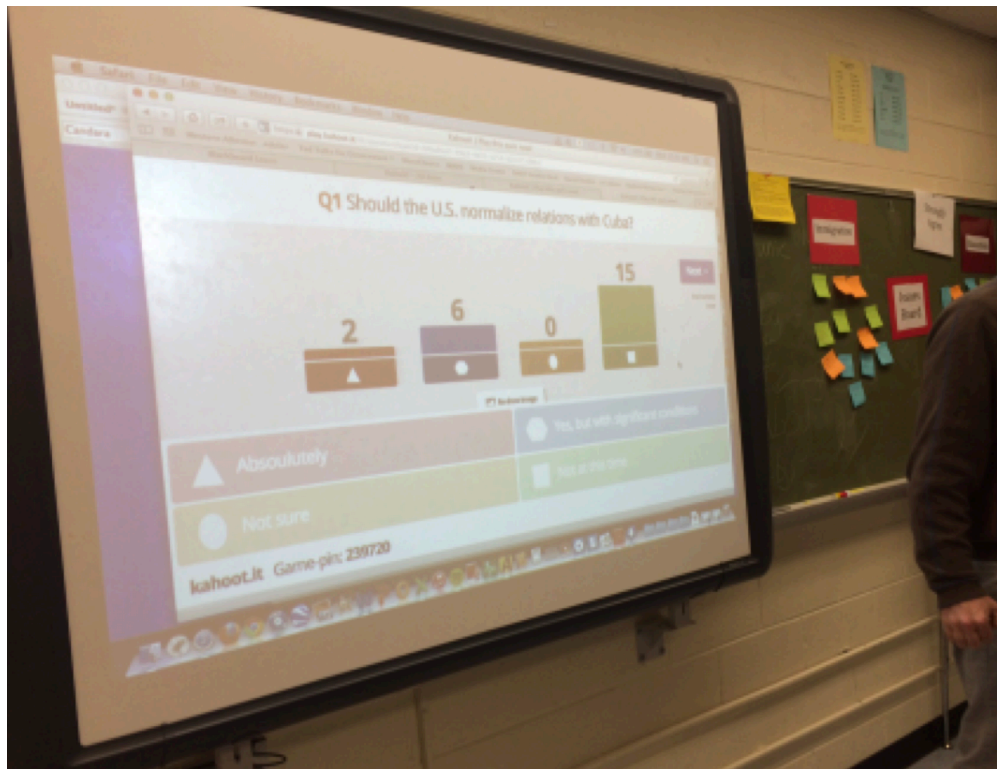students often called him by a pet name and demonstrated their sense of ownership of

Figure 33. Mr. Grayson lecturing in front of his interactive white board,
using online app, Kahoot!, to poll students.

their classroom by freely writing messages on his chalkboard. His interactions with them

were relaxed and laced with a self-deprecating wit. This slightly cynical, self-effacing

humor—so effective with high school students—surfaced on my first classroom visit

(observation, 1/27/15). He introduced me to hisAdvanced Placement (AP) Government

seniors (who seemed concerned about the purpose of this interloper) by saying, "What I

do is the subject of her research. Or what I don't do." As he lectured in front of an

interactive whiteboard (Figure 33), he ignored email notifications that kept popping up on

the screen. Eventually a student sent him an email titled, "Haloooooo!" Mr. Grayson

laughed with the class and finally walked to his desk to close his email, saying, "There

goes my evaluation." Comically jumping to his defense, a student called out, "He's a

really good teacher!" It was clear Mr. Grayson had built strong connections to the

students who clearly trusted and admired him.

When I began observing Mr. Grayson (observation, 1/27/15), his school year had

become particularly complex, and he was feeling the heat of "juggling things"—

committees, mock-congress, administration certification coursework, and a new baby at

home (informal conversation, 1/27/15). His schedule had not turned out the way he had

predicted back in July 2014, when he expected to be teaching government to seniors and

to have a single new course: World Geography. Days after agreeing to pilot the app, and

while still on his summer vacation, the district altered Mr. Grayson's schedule:

> 1st and 2nd: 'MISSION" (World History to 1500)
> 3rd: Advanced Government
> 4th: World Geography
> 5th and 6th: Planning
> 7th: AP Government
> 8th: Advanced Government

Whether it was the result of this unexpected course load (i.e., four different preps) or his

general working style, Mr. Grayson spent the year "piecing it together, as per

usual" (observation, 2/9/15). Some days in the brief minutes between classes, I observed

him typing the class agenda, projected onto the interactive whiteboard, seemingly from

his head. Another morning he mumbled, "I hope there are announcements today. I have

more work to do" (observation, 2/3/15). That same morning he opened his government

lesson by saying, "We are going to consider a quotation. I just thought of this. I forget

who said this—somebody smart. I'm paraphrasing…"

Mr. Grayson seemed conscious of this harried, improvisational style and remained good-natured despite the obvious stress of overwhelming inputs. For example, on a Monday he reported to me upon arrival, "So, I did have some ideas for Wednesday. I was going to do some music and dance to express interest in Latin America … See, I'm thinking ahead …" (observation, 2/9/15). In another instance, when I pointed out that he had misspelled a word in an exit ticket, he replied casually, "One, I do things in a hurry. Two, I don't really care—I'm not so OCD. If they don't think I know how to spell Congress, then we have some fundamental problems with trust" (observation 3/11/15).

Mr. Grayson's contexts. While he claimed to have a "seat-of-my-pants" style (interview, 12/14), it is likely that this frenetic delivery was due to the challenges of that particular year and set of circumstances. I observed him briefly in each of the following courses: MISSION (a collaborative History/Reading course), AP Government, and World Geography. To help the reader understand the complexity of his school year, I have provided a glimpse of these varied contexts in instructional snapshots.

MISSION. Before the app was even ready to launch, Mr. Grayson emailed me regarding the last minute addition to his course load: "I am co-teaching one of my classes (MISSION) with two other teachers. Any chance they could have access for that one class?" (email, 8/11/14). Although AdapDif had anticipated the need for a teacher collaboration function (see Appendix J for ideas as wireframe), we still had unresolved issues with privacy (i.e., FERPA restricts access to student data, and we had not yet solved the programming puzzle). As an interim solution, I suggested that his co-teachers could have accounts, too, but the profiles would not sync with his. He said he would talk

to them but thought "having separate accounts that are not in sync might get

cumbersome" (email, 8/14). This interaction suggested Mr. Grayson initially wanted to

use the app collaboratively, but balked when would it would have complicated processes

instead of simplifying them.

While MISSON was officially listed on his schedule as "World History to 1500,"

it was actually a course Mr. Grayson had created five years prior in order to help a

population of kids he felt were slipping through the cracks. As he explained it,

> A couple of teachers and I were concerned about chronically underperforming
> kids, consistently below level readers who were failing a bunch of SOL tests.
> Traditionally [before standardized testing] they'd be passed through, but there
> was little concern about their academic development. I called it "pre-AVID."
> They were not gunning to go to college or even in the range of passing the SOLs.
> A math teacher and I spearheaded this class—people might call it a Tier II
> intervention (informal interview, 3/1/18).

In an informal conversation during an observation, he said he designed the class "based

on the theory that kids did better by reading more" because "the SOL is more a measure

of their ability to read" than anything else (personal communication, 2/11/15).   As a

result, he built the MISSION class as a two-hour course, with time to "just read, to build

community, and improve reading by reading a lot."

I observed this class only once (2/11/15) toward the end of a class period when

students seemed to be informally taking a practice SOL test using the district's learning

management system. I assumed this was an SOL prep exercise, but the co-teacher

informed me that taking the practice test provided students with a learning opportunity

because they returned to their notes or learned from each other while finding the answers.

Mr. Grayson clarified that he had pulled individual questions from Illuminate and then

imported them into Blackboard "which takes some time." To better understand the

learning, I asked a student what they were studying;

> Student: Rome, I guess. The PaxRomana?
> Another girl complains, "I don't know this!"
> Student: If we finish, what do we do?
> Mr. Grayson: Take the real test.
> Student: Ugghh! We pass the test then we have to take another one?
> The girl moans, "Oh my god! I just got a 19 on this"
> Student: Why does class take so long?
> Mr. Grayson: Because you've been answering multiple choice.

Mr. Grayson's statement suggests that he recognized the drudgery of this uninspired, test-

prep. To be fair, test practice was not indicative of the instruction I witnessed in any of

his other classes, and from a single observation, one can hardly conclude that it is fair

representation of what typically happened in MISSION. Still, the moment was

instructive as it represented a concern Mr. Grayson expressed about this population:

"These kids, I'm worried about them graduating high school. It's about, how do I

simplify this in the most basic way, which doesn't make it the most rich. There is

probably a better way … I don't drill and kill everyday … but there are those testing

moments when they have to churn out the right answers" (observation, 1/30/15).

AP Government. Although I also observed only one period of AP Government

(2/2/15), it looked very different from MISSON. From the outset of the class, it became

apparent that Mr. Grayson had strong content knowledge and an innate facility with the

concepts and essential understandings of the domain. While his comment, "I just thought

of this question," might have signaled a lack of planning, it also reflected his facility with

the content.

As Mr. Grayson launched into a lecture on the concept of *one man/one vote*, he

announced, "There's no notes for this, I'm just going to talk." As students asked a variety

of questions, he was able to provide nuanced answers (e.g., "not all justices agree on

this") and elaborated with timely examples (e.g., a Louisiana senator had just lost her seat

trying to defend the Keystone pipeline). He engaged students by punctuating his whole

group instruction with stories, humor, and music. Mr. Grayson's ability to connect with

this teenage population manifested, for example, in his presentation of a YouTube video

which he introduced wryly, "I've got a really fresh hot jam for you all about

redistricting." As the animated, Country and Western introduction segued into a Hip-

Hop/Rock section on packing and cracking (i.e., tactics in gerrymandering), the students

rolled their eyes and laughed but paid keen attention as he highlighted key ideas. When

the video concluded, he then told them, "See, you guys thought it was going to be hokey.

That was intense! Now it's your turn to gerrymander. What I want you to do is pack and

stack. You can be a Democrat or a Republican." He gave the students parameters for the

task and let them work at their tables.

As they talked in small groups, I asked students whether they were working

together or individually. A table of boys said they were working together being

Republicans, because it was easier. A girl said she was trying to figure it out herself and

then she would "tell" the group. Another group said they were brainstorming together.

After class I asked Mr. Grayson if he thought the task was equally challenging for

everyone. He responded, "About 7/8 don't get discouraged by the challenge, but for

some it is too overwhelming for them. They would never be asked to do something like

that on the AP test. Usually you are asked a free-response question, not to play a role.

It's usually identify and explain." He went on explain that the task is "like visual/spatial"

and after a pause, he reflected, "What I might have done, would be to have them draw

maps, different ways. This was a somewhat typical lecture sort of day." He often

thought aloud like this to me, critical of his choices, reflecting on how he could have

done better.

World Geography. In the email confirming he would test the app, Mr. Grayson

mentioned he was "pretty flexible, particularly about geography" because he had never

taught it before" (email, 7/29/14). This heterogeneous class was part of the new

Environmental Studies Academy embedded in the school. I observed once or twice a

week for at least two hours, and Mr. Grayson constantly bemoaned his purported lack of

geography knowledge. This meant, in contrast to government, he could neither fluidly

engage students with the stories inherent to the domain nor had he internally embedded

its learning progressions. As a result, he could not confidently deliver content through

lecture, and after an uncomfortable first half of the year, he had shifted to a student-

driven exploration of the material. An exchange in January captured how he selected the

content and how uncomfortable he felt about it:

> Mr. Grayson: I choose topics that were a combination of things that are in the
> SOL framework and were partly interesting, so that they could then share it, in
> lieu, of me teaching it directly. I don't have time to learn the stuff … My
> expectations for this class are lower. Not because of the kids but because of my
> [lack of] understanding of the big ideas of the subject.
> Moran: How do you feel about it?
> Mr. Grayson: Not great (observation, 2/4/15).

Mr. Grayson expressed that he wanted "to do better for these kids" than the first semester, while at the same time conceding, "I feel like you could throw a dead cat in here, and they'll probably pass the SOL" (observation, 1/30/15.). True to his email, flexibility became his modus operandi in this class, and it was in this course that he used the app first and with the most intensity.

   Case #2: Mrs. Morrison. Like Mr. Grayson, Mrs. Morrison's skill and experience was evident in her easy command of the classroom, connectivity to the students, and instructional dexterity. As a teacher with an elementary background working with 12 year-olds, however, these traits manifested entirely differently.

   Mrs. Morrison established clear and consistent expectations that she insisted students meet, while deliberately building authentic relationships with them. For example, she always tried to stand in the doorway because she liked to greet the students (observation, 3/19/15). During class, she quietly and consistently affirmed students, once during a poetry lesson whispering to an AVID student, "You are going to be our repetition expert" and at the the end of that same class, telling another student, "You did a particularly good job today in group work" (observation, 2/24/15). She balanced this warm affect with a resolute delivery of consequences. A typical exchange with a student about homework illustrates her empathetic, but firm, demeanor:

>   Student: I swear. I finished it, but I left it at home.
>   Mrs. Morrison: You are breaking my heart *[Not sarcastic.]*
>   Student: I have it. I know where it is. My little brother talked to me, and I put it down.
>   Mrs. Morrison: *[Listens patiently]* You won't be able to participate in your triad without the text (observation, 2/12/15).

She similarly enforced management rules. When a student asked to go to the bathroom at

the beginning of class, she told him if he did, he had to go before or after class for the rest

of the nine weeks (observation, 2/24/15). On another day, a student interrupted a writing

conference, holding a green bathroom pass. She looked up and said, "No – seven

minutes to the bell" (observation, 3/3/15). While these systems provided a sense of order

to a class with a great deal of movement, it was unclear if students felt managed instead

of lead.

Like Mr. Grayson Mrs. Morrison created an environment about which students

felt ownership, although the structures were more visible than in his room (e.g., Students

were free to write on Mrs. Morrison's walls, but with prompts (see Figure 34)). Even

when students seemingly scattered to different areas of the room after whole group

instruction, they pulled bean bags from a corner pile or moved to a reading nook with a

sense of order. In one instance, when students dispersed to groups, I asked a student how

he knew where to go. He pointed above his head where a laminated blue circle hung

from the ceiling. These numbered circles were arranged clockwise around the room

above clusters of desks allowing Mrs. Morrison to flexibly group students (observation,

2/10/15).

Mrs. Morrison's teaching methods were visible, as well—consciously modeling,

maximizing time and feedback, and intentional using student-driven discussions

strategies. For example, she allotted time daily for students to do independent reading

and eat a snack, and she joined them for the first 10 minutes, pulling her book from a tray

on the wall (Figure 35; observation, 3/19/15). After modeling adult reading behavior, she
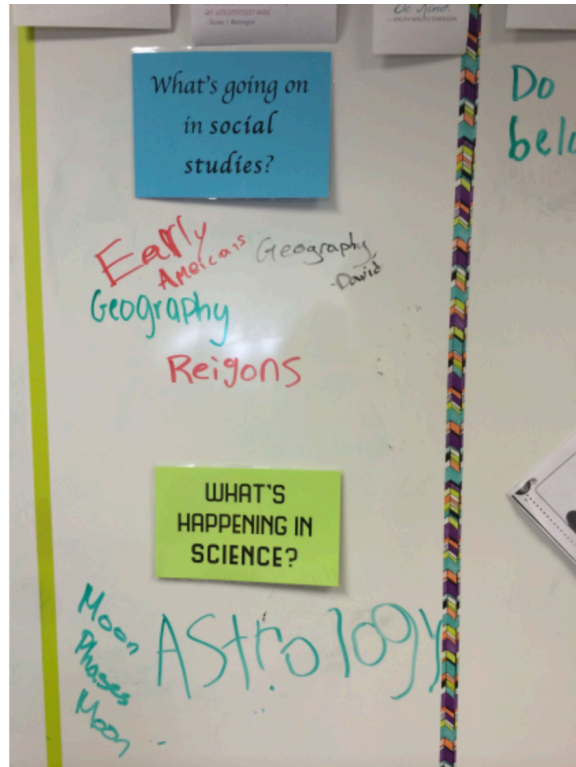
Figure 34. Photo of one of Mrs. Morrison's whiteboards, with organized student scrawl.
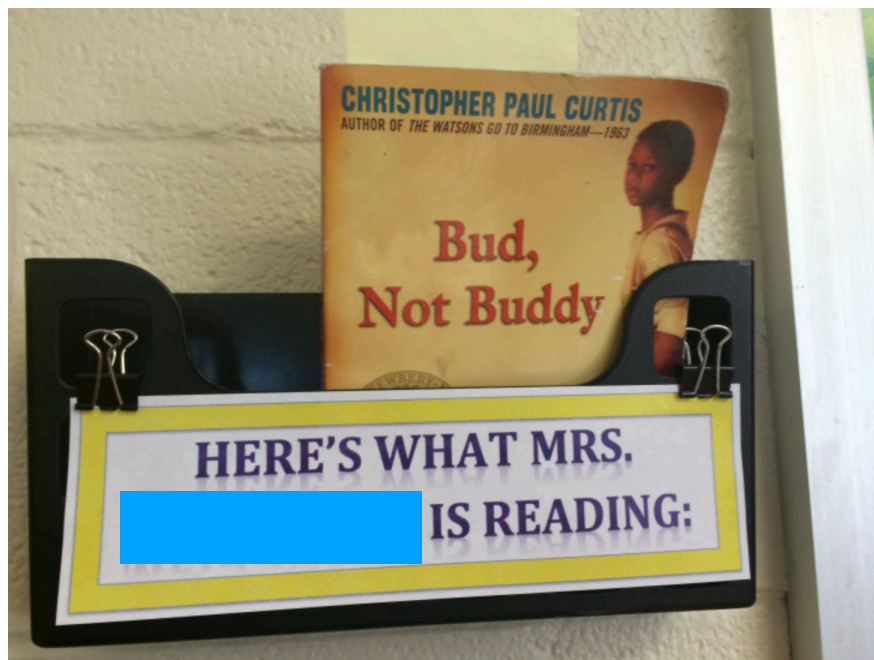

Figure 35. Photo of Mrs. Morrison's reading tray, on the wall next to her desk.

used the remainder of the time to conference with students. On another day, she flipped

through a stack of reading response notebooks while students researched, providing

feedback on prompts assigned the day before. When asked about her feedback practices,

she said she tried to give feedback immediately because "otherwise it is not as

powerful" (personal communication, 2/12/15). In the same conversation, she added that

she liked the notebooks better than single sheets of paper, which they lose or throw away,

because it allowed them to "look back to previous weeks to see how they are improving"

and what they need work on. Mrs Morrison's visible methods and systems certainly

differed from Mr Grayson, but they both authentically connected with students and

created learning environments in which students felt a degree of freedom and ownership.

  Mrs. Grayson's style. Because I only observed Mrs. Morrison in one context, her

Advanced ELA block, I did not witness instructional variation that I did with Mr.

Grayson. In that single context, however, I identified particularly strong traits in her

style.

  Systems-manager. The most common sentiments I expressed in memos about

Mrs. Morrison involved her routines: "VM expertly integrated routines into her

classroom management. This allows her to concurrently provide a great deal of freedom

within a structured system" (memo, 4/25/15); "She is very fluid with routines.

Experience and confidence shows here" (memo, 2/10/15); "She has a visibly well-

managed classroom. Routines are in place. Time is structured and and clearly announced

—Does this allow for more freedom in learning, because she is not constantly having to

manage behavior?" (analytical note, 2/12/15).

Implicit in her routines was the goal of slowly guiding "students as they begin to

take ownership over their own learning" (teacher biography on district website, 3/5/18).

For example, I never observed her bark an order at a student and often made her

reasoning explicit to them. During independent work, in order to quell a rising surge of

noise, she announced, "If you are at a seat where you are talking, that means that seat is

not working out for you in working independently, so you should find a new

seat" (observation, 3/17/15). Finally, I noted when she circled around to small groups,

she was often eating. She explained, "It helps me to eat my snack while I circle around to

homework groups so that I don't talk. Your instinct as a teacher as is to talk. If I eat the

snack, they don't look to me to lead the group" (observation, 2/24/15). Her routines

were transparent, deliberate and with an eye toward student self-regulation.

Low-tech tool user. In stark contrast to Mr. Grayson, who characterized himself

as being a "big consumer" of technology and "ahead of the curve" compared to a typical

high school teacher, Mrs. Morrison defaulted to paper/pencil processes and a document

camera. She tucked her desk in the back corner of the room, while the screen and

computer inputs were across the classroom making the connection of the laptop to the

screen arduous. When asked about the configuration, she replied, "I'm opposed to sitting

behind my desk all the time, and if it were up there, I would" (observation, 2/24/15).

Her desk was often buried in stacks of paper, and I observed, "VM seems to be a

teacher who still relies heavily on analog [vs. digital] tools — hard copies of homework,

folders, index cards" (analytical note, 6/30/15). For example, when a student returned to

school after an absence, she sent him to a bookshelf for the "While You Were Out" binder
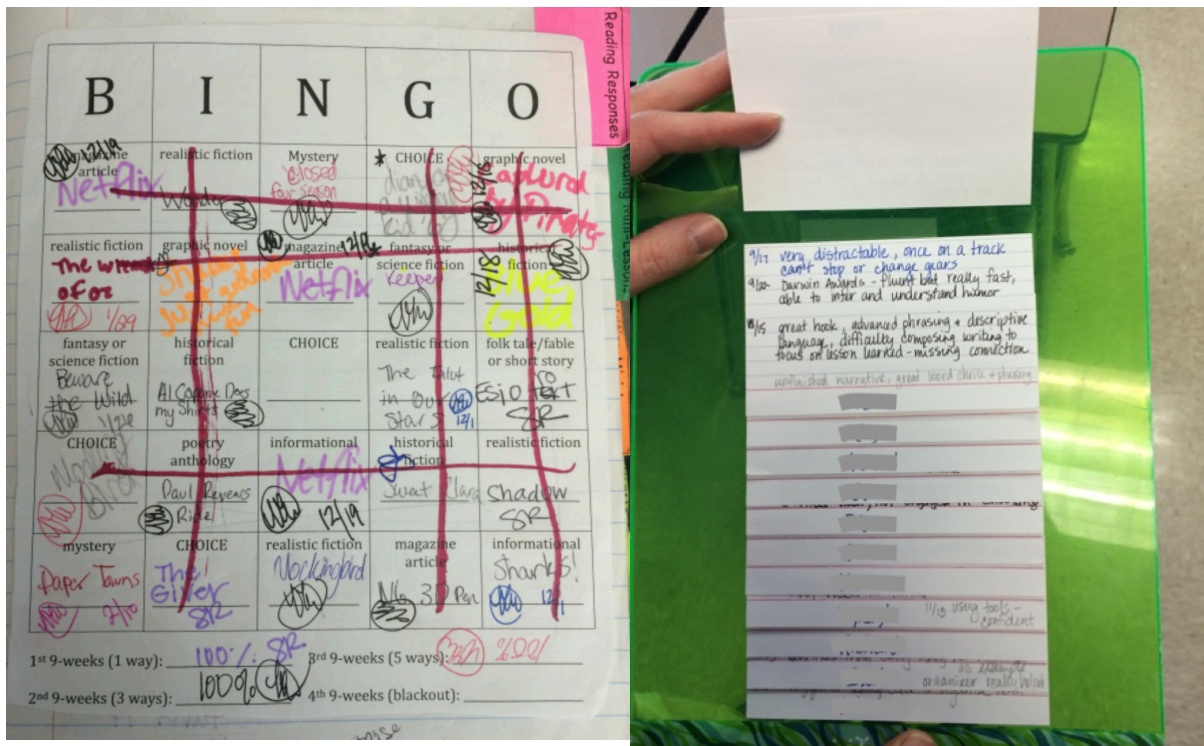
Figure 36. "Analog" tools. On the left, a page from a student journal. On the right, Mrs. Morrison's note-taking device for collecting data about students.

where she put copies of classwork when she remembers. She also noted that she had an

"extra copies of homework" binder (observation, 3/17/15); by contrast, Mr. Grayson

expected students to find missed work on Blackboard. Students wrote in bound reader's

journals into which Mrs. Morrison glued an envelope and slid changing prompts, and

which included included choice tools like a bingo board for students to record books as

they read them across genres.

She seemed to prefer non-digital tools for her own processes, like taking notes

about students and forming groups. For example, she used a clipboard (Figure 36) with

tiered index cards onto which she took notes about individual students. She used sticky

notes to collect data from students and to form groups based on that data. To create novel
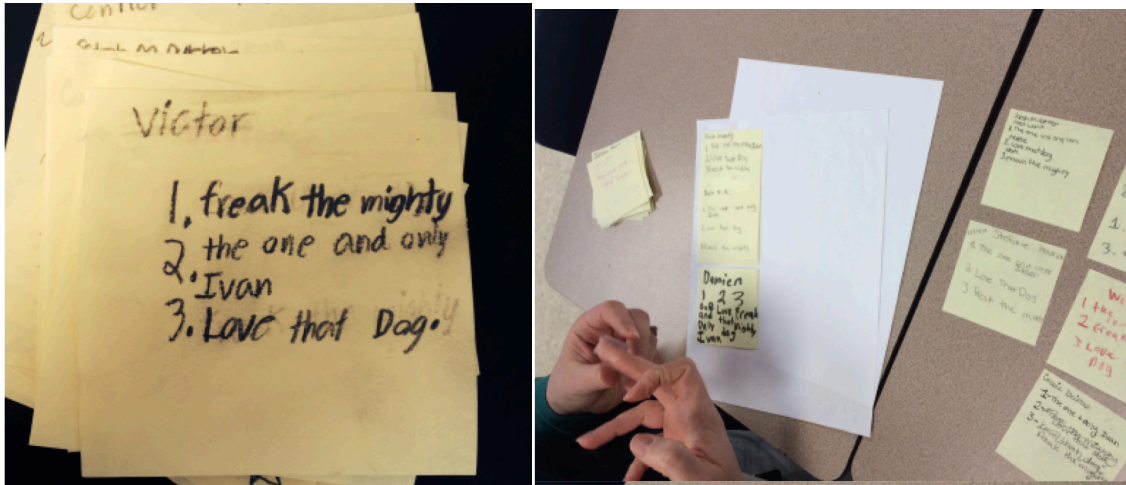
Figure 37. A student's top three choices for book club (left), and Mrs. Morrison transforming the data into small groups (right.)

study groups she first collected students' top three choices on sticky notes and then

spread them out on a cluster of student desks (Figure 37). She then looked for a "fair split

of abilities" making sure the group had "a stronger student who can model high level

questions and answer them," followed by behavior issues (e.g., "They are like Mutt and

Jeff, so they can't be together") (think aloud, 2/7/15).   When I asked about learning

preferences, she said she already had data on some of these students, and their IEP

allowed them to read alone or with a teacher, so this was data she did not need to gather

again. Each student had written his or her top three preferences, and she then tried to

accommodate their first or second choice. She taped the sticky notes to a piece of paper,

labeled it with the novel title, and filed it in a manilla folder. Like many of her

instructional and planning routines, this grouping process easily transferred to the app.

Participants' App Use

Unsurprisingly, teachers' engagement with the app reflected their respective teaching rhythms: Mr. Grayson used it in fits and starts, while Mrs. Morrison moved at a measured pace, while. For example, he began with an enthusiastic burst of activity in August, ready to use the app before school duties took over (i.e., "You will be able to find me at the high school from the 14th on. I don't have any indication of how our overlords plan to consume our time during pre-service week, but I am guessing that the 14th will pretty much be spoken for"; personal communication, 7/29/14). Conversely, Mrs. Morrison calmly waited for school routines to settle before she tried the app. Once the tool aligned with one of her practices, taking notes about students, she used it immediately and independently in October. While both teachers used the app tentatively during the unguided research phase, in the sections below, I focus on the app use I observed in the classroom between January and April.

Case #1: Mr. Grayson. By the time I arrived for classroom observations in mid-January, Mr. Grayson was floundering in World Geography and had made what he called a "cry for help" to the district's instructional coaches:

> I needed some balance between me delivering instruction and them [the students] being self-directed. I had some notions about some things that I wanted to try. I wanted to teach them some sort of case study approach, but I couldn't find a good resource, and I just wasn't going to have time to create it myself (interview, 3/2/18).

Together, he and the coaches designed the "Lens Project" which, according to the KUDs (i.e., learning goals written according to what students should know, understand and be able to do) meant students would "independently conduct research" and "produce high, quality comprehensive projects" in order to understand that "humans have varied
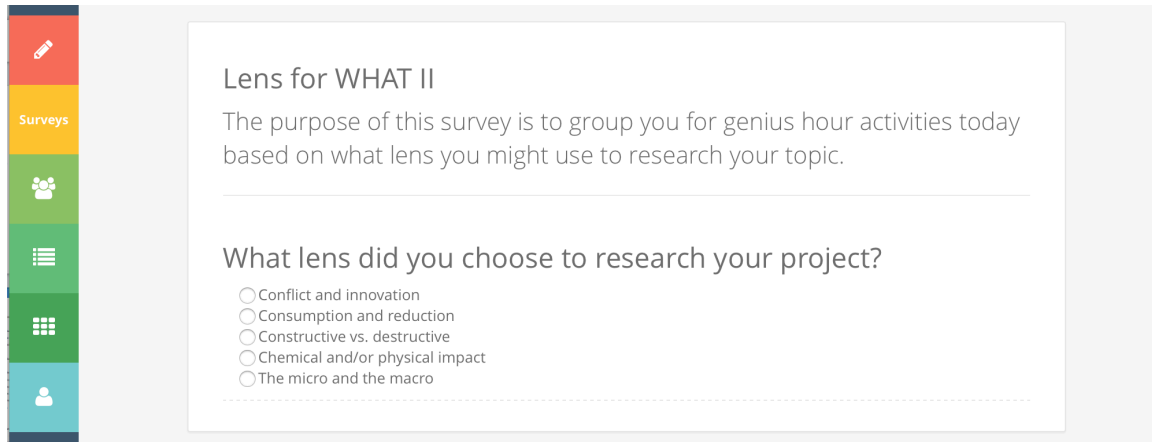
Figure 38. Survey question asking students which lens they selected for their project.
Screenshot of Mr. Grayson's app account.

relationships to the world around them, to one another, and to history," and "human

influence can be constructive as well as destructive" (Google Doc, see Appendix K). The

app quickly became entwined with how he executed the project, and, in his words, gave

him "a little bit of a lifeline" (observation, 3/11/15).

As a tool, the app helped Mr. Grayson convert his improvisational instructional

impulses into immediate actions. For instance, the idea to create a survey would often

occur to him during class. An early lesson (observation, 1/30/15) required students to

chose a lens to apply to their investigation. Midway though the class he decided to use

Survey to record their choice and quickly created an exit ticket (Figure 38). The

following week he ruminated aloud at the beginning of class, "I think I may do another

survey at the end … I might want to recycle this idea for Friday, shuffle groups. Same

theme, different groups" (observation, 2/4/15). The following week he opened AdapDif

at the beginning of class to revisit the individual instructions he had assigned to each

group (Figure 39). He thought aloud, "What I might have them do as groups as they

Figure 39. Preview of groups made in GroupMat with different instructions in each group. Screenshot of Mr. Grayson's account.

finish their work, I might give them 15 minutes to decide what the [summary] bullets

would be." I offered, "Could it be, 'What are the three big ideas from your group?'" He

liked that idea and said with a laugh, "We could actually use our survey data to inform

what we do on Wednesday" (observation, 2/9/15).

As Mr. Grayson's confidence in AdapDif grew, his instructional use became more

sophisticated. His first surveys simply asked students to rank their interest in topics,

which the tool then auto-grouped on the GroupMat. As the survey preview in Figure 40

demonstrates, he soon fell into a rhythm of checking in with students about their

processes (e.g., "What was your greatest strength as a group member? What could you

have done to make the task or group more successful?") and eventually their learning

(e.g., "What was something you believed about Latin America before this activity? How

has that changed or been reinforced?") No data exists to determine whether he used these

student response to inform subsequent instruction.

While the app helped him move from a teacher-directed to student-directed

model, it was not without anxiety. In fact, his comfort with the app grew alongside his

discomfort in not knowing what his students were actually learning or how they were

functioning in small groups. As he continued to use the app to structure his instruction,

toggling between surveys and grouping, he wrestled with the direction of the class. One

day he worried aloud, "How do you make a coherent lesson/unit? How do I string this

together?" He chastised himself for not having clarity about his instructional path, which

he attributed to a lack of "time I have to think it through." Concurrently, he rationalized

that this was the "obvious" class to teach this way because "what they are losing from me

Survey Responses

Think about your role in your group work for Latin America. What was your greatest strength as a group member? What could you have done to make the task or group more successful?

Student 0	I read the articles and provided information from them to use on the poster.
Student 1	My greatest strength was that I think I had some good ideas and I think I did a good job at making sure the group did not get off task. To make the group more successful, I think I could have communicated with my group a little more to begin with.
Student 2	I was another actor we all worked together on making the skit so we all had the same jobs, I could of done better if we did extra background on the article.
Student 3	Artist/creative desinger
Student 4	I was a helper not a leader I could be more of a leader

Survey Responses

What was something you believed about Latin American before this activity? How has that changed or been reinforced?

Student 0	I thought that more countries would actively try to stop drug trafficking but it surprised me to find out that some are being passive about it instead of taking a stand.
Student 1	I thought that the diets of Latin American contained more meat before this activity. Through studying the topics, I realized that meat makes up a lot less of their diets and instead, oil, sugar, and grains make up a lot more of their calorie intake.
Student 2	I knew that the drug trade was a large buissnes in central america, this activity has just reinforced this.
Student 3	I believed that there was a lot of drugs in central america and I realized that this is true, its very prominent.
Student 4	I never thought they produced the exports they did, i have learned more about the country and how they make money with their productions and consumption.

Figure 40. Student responses to a Survey question asking students to assess their role in group work. Screenshot of Mr. Grayson's app account..

is not much versus lecture" (observation, 2/11/15). He felt most successful when groups

presented their work to the class at the end of a day of exploration, during which time he

could comment to create a more "uniform learning experience." He explained, "When

we do jigsaw-y things, I worry about what the learning looks like. I think presenting at a

station is better for them if they really have distilled the understanding and can articulate

it well" (observation, 2/9/15).

Mr. Grayson's planning shifted for his next unit on Sub-Saharan Africa. Upon

walking into his classroom on a Friday, he told me, "So, this last unit was kind of cool.

We got the group thing down, but we didn't have a point, or we manufactured a point

along the way. This time I have a point to base the unit around, and that will help

me" (observation, 2/25/15). He continued, "I'm excited about the next unit, because

there is some forethought. I have until Wednesday, and I have some notes." He claimed

to have "stolen" ideas from a university website—after googling the five themes of

geography he got "some ideas about how I could articulate a theme or enduring

understanding." By Wednesday he had selected a theme: Movement brings life to a

place. He decided he would weave it throughout the unit, "even in the

homework" (3/4/15). As a result of this forethought, he was able to write both an

entrance and exit question that not only collected students' topical interest, but also

assessed students' understanding (Sub-Saharan app use illustrated in Table 4). I did not

observe how or if he adjusted instruction according to those student responses.

Finally, despite his misgivings about "jig-saw-y things," Mr. Grayson assigned a

culminating activity for the unit in which students split time between teacher and learner

roles as they rotated through groups. When I asked him if he was worried about the facts

being delivered inaccurately, he replied, "Of course." Probably related to that

discomfort, he closed the lesson by returning to his place in front of the whiteboard to ask

Table 4
Mr. Grayson's app use for Sub-Saharan Africa Unit

Survey Title	Survey Questions	Grouping
(3/4) Sub-Saharan Unit Entrance Ticket Intended for you to reflect on the enduring understanding of this unit and to express interest in a topic for which you will make a concept map.	Give an example of how movement (people, ideas, physical systems, materials and etc.) brings "life" to a place. Today, we are going to make a concept map about movement. Which topic interests you the most?	(3/4) "Movement Groups"
(3/4) Exit Ticket Evaluating your understanding of the enduring understanding.	Give a specific example of how movement (people, ideas, physical systems, materials, etc) brings "life" to a places in Africa	
(3/11) Human Migration We are Gaugin what human migration you'd be interested in, connecting African physical geography to migration.	Which human migration are you most interested in?	(3/11) "Migration Groups"
(3/18) Entrance ticket Wrapping up product movement and onto disease movement	How has diamond mining and the diamond trade changed the cultural landscape of sub-Saharan Africa? Which topic interests you the most?	(3/18) "ideas"?

summarizing questions. In an analytical note, I commented that he seemed to be calling on one of his strong students for correct or elaborate answers, and he seemed to rush the students in their answers. I recorded, "No wait time. Is this because he is concerned about time? Or about getting the right info out?" (analytical note, 3/21/15).

    After the lesson he admitted the jigsaw appealed to him because he would have struggled to create a "unified activity where they all do the same thing." He said he had an AP resource with activities connected to the bigger ideas, and so I asked if, in his AP

Table 5
Mrs. Morrison's app use

QuickNotes	Survey	GroupMat
Workshop Conferences (9/23/14-10/30/14)	"Writing Interest Survey" (1/13/15)	Homework Triads (2/11/15)
	"Book Club Choices" (2/24/15)	"Book Clubs" (4/10/15)
	"Writing Workshop Mini-lesson Choices (4-23-15)	"First Choice for Writing Mini-Lessons" (4/29/15)

class, he let the students explore and make their own factual connections to the essential

understandings, as he did that day. He replied, "No. This would be a new way of

teaching for me. It would be a revolutionary way of teaching for me" (personal

communication, 3/21/15).

        Case #2: Mrs. Morrison. Mrs. Morrison's use of the app was as systematic and

judicious as her teaching style would suggest. She interacted with the app only seven

times, outlined in Table 5: She used Quick Notes during her reading/writing workshop

conferences (between 9/23/14-10/30/14), after Winter Break she constructed a "Writing

Interest Survey" (think aloud, 1/13/15), a month later she formed homework triads with

GroupMat (think aloud, 2/11/15), and finally, she used both the Survey and GroupMat

together to replicate her sticky-note process to form "Book Clubs." (She created the

groups on 2/24/15 and sent them 4/14/15). Like Mr. Grayson, she used the app almost

exclusively in one context, her Advanced ELA Block, a class that she was "not worried

about" (observation, 3/17/15). Her use patterns did not tumble around in a rambling and

hectic narrative like Mr. Grayson's but instead were clean, episodic, and easily broken

into functional categories described below: collecting data as Quick Notes, writing-

interest survey, homework triads, and book club choices.

Collecting data as Quick Notes. During an interview with me between unguided

and guided app use, Mrs. Morrison explained how she used Quick Notes to collect data.

She reported that she "really liked using the app" and had used the Quick Notes to record

student data during reading and writing conferences (interview, 12/14). These notes

tracked:

- students' writing progress (e.g., "Typed drafts in word on laptop, but now has

  loaner. Will focus on lead today in google drive and then put together

  tomorrow"),

- work habits (e.g., "First time on the Griffin; great focus and concentration;

  working hard and asking good questions.),

- reading interests (e.g., "found a book he loves - *Passport on a Plate*. Made

  his own sticky note code of a chef's hat for recipes that he wants to try), and

- interactions with other students, (e.g., "a little overwhelmed when Sally

  worked with him on character traits, keep an eye on this). (See Appendix L

  for a list of her Quick Note examples.)

In the interview I conducted between unguided app use in the Fall and guided app

use in the Spring, I asked if she had been able to modify instruction based on those notes.

Mrs. Morrison said , "[I] was able to make some decisions about mini-lessons that I did.

I sort of said, 'This is a weakness I'm seeing … let's do a mini-lesson on this, or let's

meet with a small group about this.' So, I could even though I didn't use [the GroupMat],
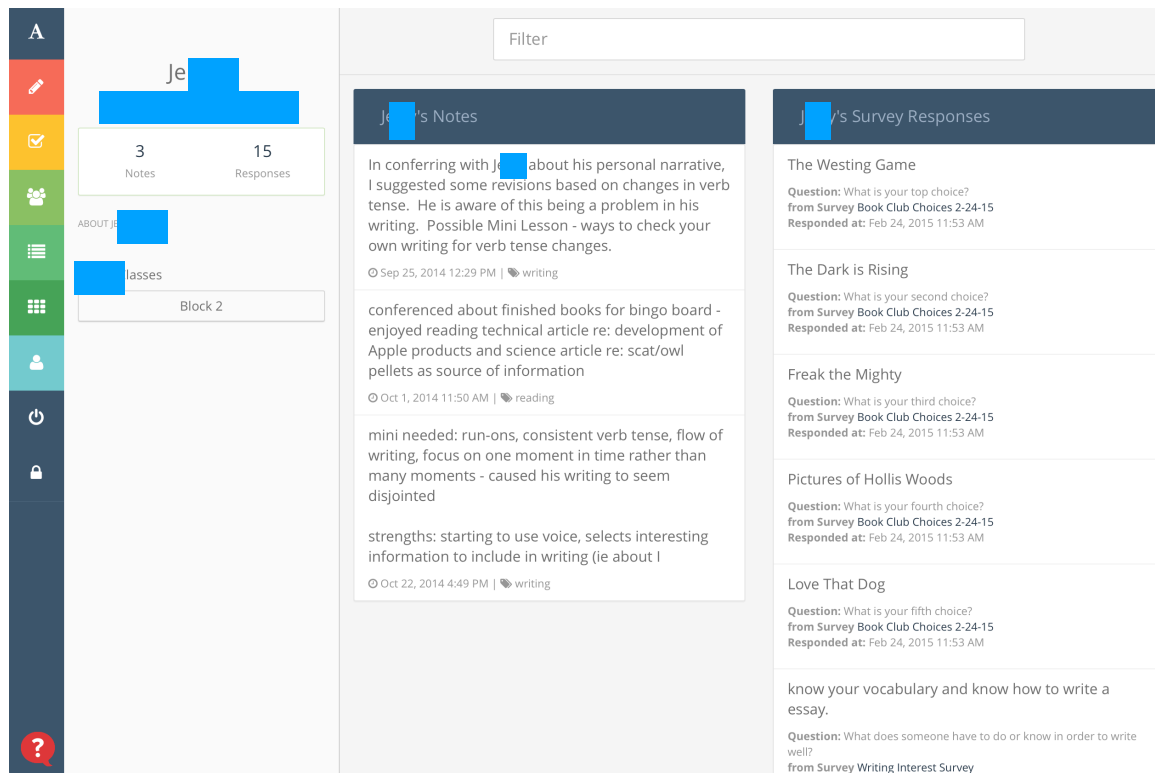
Figure 42. Student profile in AdapDif. Screenshot from Mrs. Morrisons' app account.

I looked at my notes" (12/14). For example, in her QuickNotes she recorded, "In

conferring with Jerry about his personal narrative, I suggested some revisions based on

changes in verb tense. He is aware of this being a problem in his writing. Possible Mini

Lesson - ways to check your own writing for verb tense changes" (see Appendix L).

During the interview she further reflected on how she used the data she collected,

> As I was scoring the person … I also used [the app] to document things that I was
> telling them [in the conference], because I didn't really have a good place to keep
> those notes. You know when you give the kids feedback on a rubric, or you want to
> notice in sort of an overall picture of what was difficult or easy for them? I wanted
> to make notes on that. So, it also helped me do comments on report cards, because
> we give like a strength and weakness comments on them" (interview, 12/14).

She referred back to student profiles (see Figure 42) for assessment purposes, and in this

way integrated the app seamlessly to her pre-existing practice (e.g., recording notes from

student conferences).

  Writing Interest Survey. Mrs. Morrison did not create a survey until I began

observing her after Winter Break, although she reported in her interview that she "put

thought" into what questions she might ask. As she thought aloud, she claimed she

wanted to better understand her students' reader and writer identities and get a "better

picture of where they'd like to go in the next nine weeks" (think aloud, 1/13/15). To that

end, she included questions such as, "Look at your Writing Goals that you set for yourself

earlier this year. Which domain did you choose to focus on? Hint: look in your journal.

If you chose Organizing and Elaborating, what steps did you select to reach your

goal?" (see Appendix   N). She also suggested that the survey signaled to students that

she had "an interest in what they're thinking" (She pulled questions from the appendix of

In the Middle: A Lifetime of Learning About Writing, Reading, and Adolescents (Atwell,

2014) and added a question from a teacher she followed on Pinterest (e.g., "Which should

you enjoy first, book or movie?") As I sat with her while she created these separate

reading and writing surveys, she wondered aloud if two would be redundant. She rarely

asked for my instructional opinion during the study, but in this case she added, "Maybe I

could get your input? I don't know what research says." She ultimately delivered the

survey to her 2nd Block students two days later (See Appendix N for items in the Writing

Survey).

Homework Triads. Students routinely checked homework together in small

groups at the beginning of class. Mrs. Morrison invited me to observe as she built these

heterogeneous groups or "homework triads" in GroupMat. As she thought aloud, she

made sure each group included "somebody who I know is close to being right or

confident enough to share" and tried to balance boys and girls, but "it's work" (think

aloud, 2/11/15). She also considered the combination of temperaments:

- He's combative; it's hard for him to give when he is wrong.
- The were together last time.
- We'll see how Student A works with Student B; he's very kind but lacks in comprehension.
- Student C is not identified but is on the spectrum.
- Student D gets impatient because she is quick and bright and gets things fast, so it's hard for her if she doesn't have someone like her.
- Student F has recently been having way too many conversations with Student G (think aloud, 2/11/15).

While these groups could have been projected from a laptop through as app (see

Figure 43), she used the document camera to then from a print sheet of paper (Figure 44).

Because the app's printing format was not refined, she spent extra time on the school's

printer manipulating the image (also because she did not know how to adjust print

settings well.) During class I pointed out that the app could have automatically sent those

groupings to students in their emails. She thought about it and replied, "Yes, because

today they are using the laptop for their performance assessment. It is nice to have both

options" (observation, 2/13/15). This comment prompted me to reflect that she was more

apt to use the tool as it fit into her general workflow (analytical note, 2/13/15).

Book Clubs. When I walked her through the app updates between guided and

unguided use, Mrs. Morrison realized she could use the app to replicate her sticky note
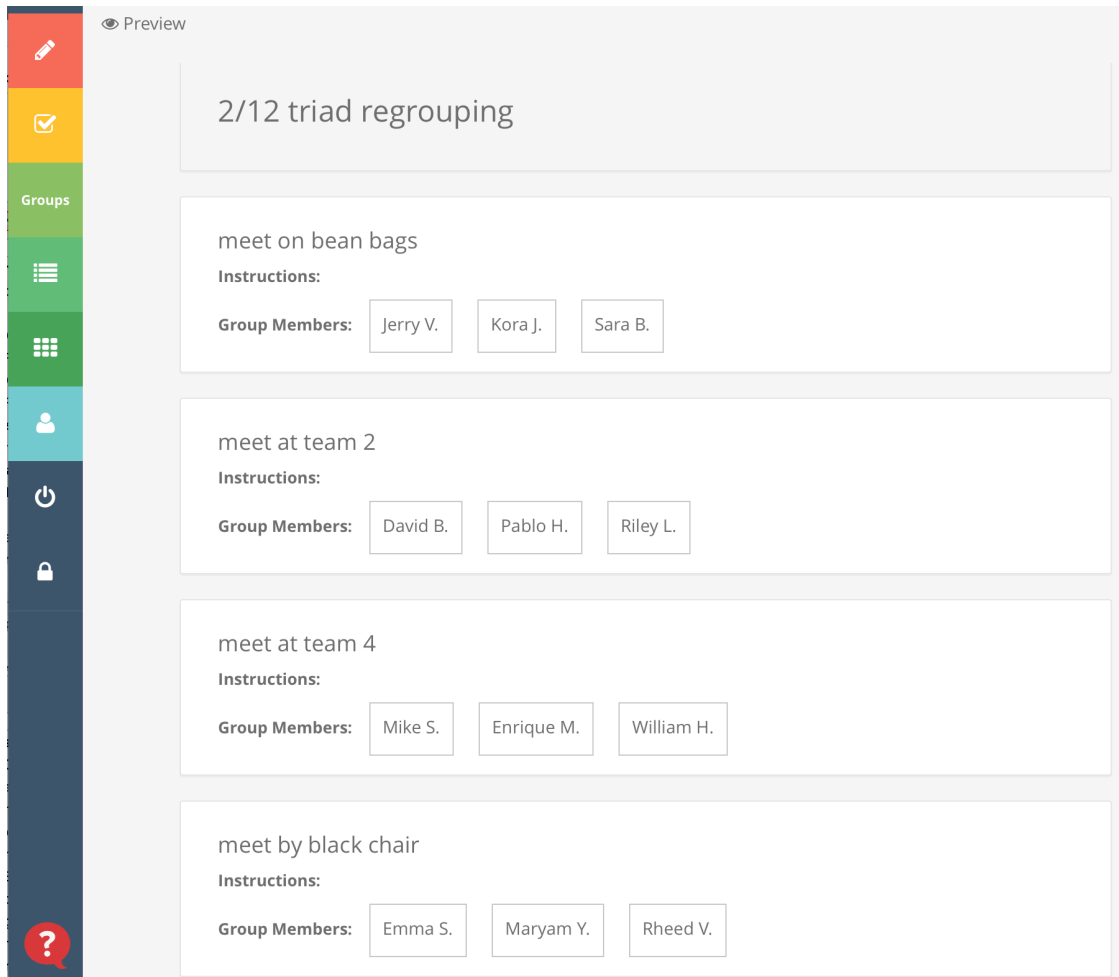
Figure 43. (Projectable) alternate view of homework triad in app. Screenshot from Mrs. Morrison's app account.
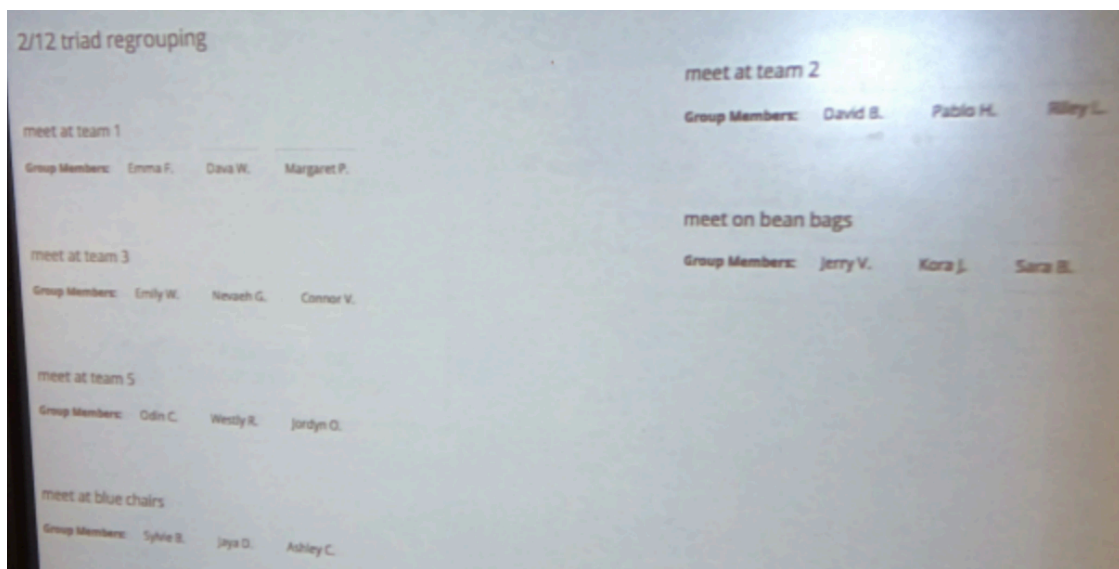

Figure 44. Homework triads projected using document camera in Mrs. Morrison's class.

grouping process:

> So, if I was doing Lit Circles, could I use that survey feature? Because usually I
> will introduce between four and six books, and they rank their first choice,
> second choice. So, could I do, 'What's your first choice? What's your second
> choice?' Then use that [the GroupMat] to sort them? (interview, 12/14).

She, in fact, eventually created her lit circle groups using those questions and the

GroupMat to sort students into groups based on their choices. When she was ready to

design that survey at the end of February, she again allowed me to both observe and

record her movements using a screen-casting software. This was particularly helpful

because this interaction with the app involved more steps than the others: She used the

auto-group function on the GroupMat, in which the app places students into groups based

on responses from a multiple-choice question (e.g., What was your top choice?) She then

compared this grouping to their second choice and/or Quick Notes she had recorded

about the student (see Figure 45).

Adding another level of complexity to the grouping process, she also considered

students' reading levels. She opened the AdapDif app on her MacBook while

concurrently looking at her students' MAP (Measures of Academic Progress) scores on

her PC laptop. She expressed frustration that she did not have mid-year fluency scores:

> In the past it's helped me when I'm setting up book clubs. If their fluency is very
> different, for the person with the lower fluency there isn't a real push … to keep
> going and to keep up with everybody. Then you end up with one person with too
> much extra time, and one person who is feeling behind the whole time (think
> aloud, 2/27/15).
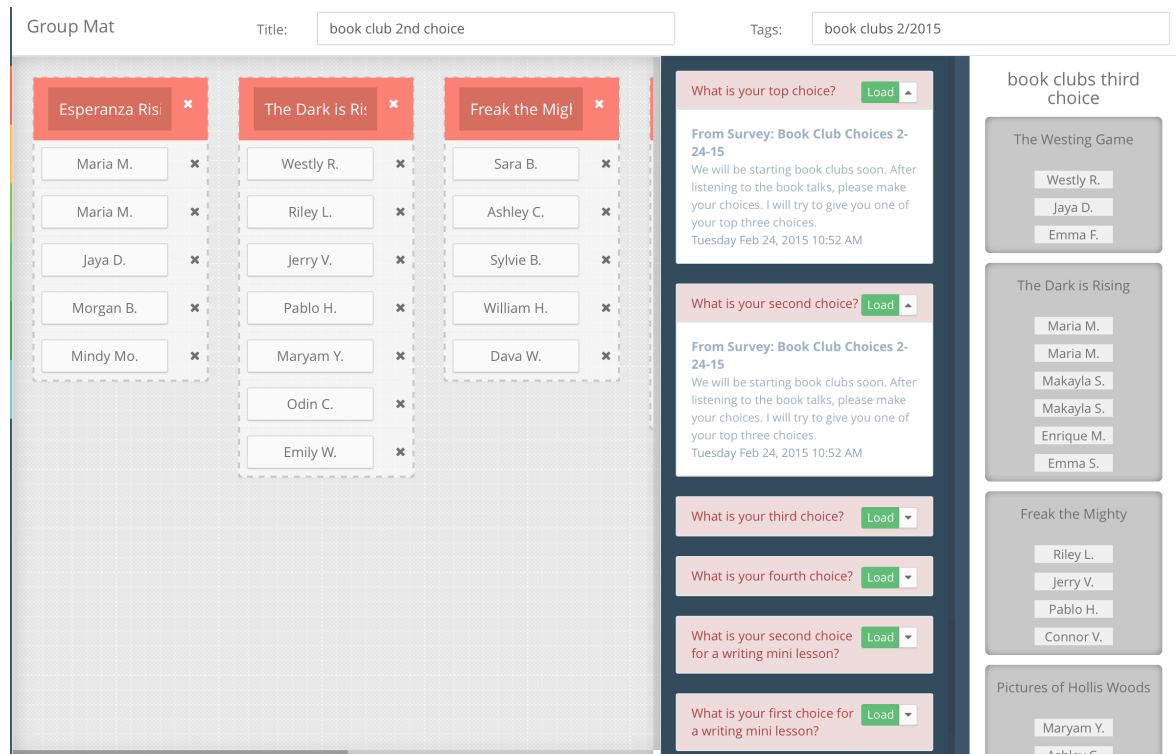
Figure 45. GroupMat displaying other groupings and survey questions open for
comparison. Screenshot from Mrs. Morrison's app account.

She rejected SOL data for grouping in favor of MAP data, as the former compares

students to a "6th grade level versus comparing them to something that pushes them as

far as they can go."

The following vignette captures how she weighed a student's readiness and

interest in his group placement:

> Mrs. Morrison: Ok, so Student X is in that group, and she'll enjoy that book, so
> I'm going to leave her there. Student Y, he's in *The Westing Game* group. I
> actually feel like he might do better in the other one.
> Mindy: Which other one? Why's that?
> Mrs. Morrison: *Freak the Mighty*. *The Westing Game* is — although he comes up
> as 10th grade on here consistently [referring to his MAP scores]…
> Mindy: What does that mean?
> Mrs. Morrison: So, according to the MAP testing, his gaps in learning begin in
> 10th grade. So he's a proficient reader. It doesn't tell me about fluency, but I feel

> like content-wise Student X would be more on top of the vocabulary and the
> difficulty of that text than Student Y. If he had asked for *The Dark is Rising,*
> depending on the group, I might leave him in it, but I might pull him from that
> one, because it's a really challenging text … *The Westing Game* just has a ton of
> characters that you have to keep track of, but I have a chart that helps with that, so
> I don't have to move him … (think aloud, 2/27/15).

As she contemplated student' readiness (i.e., MAP scores) against the complexity of the

text and vocabulary, she also considered scaffolds that would support him with the more

challenging text (e.g., "I have a chart that helps with that"). Because she based group

configurations, in part, on student reading level, she only promised students one of their

top three book choices. "If I can get them one of their top three choices, I'm ok" (think

aloud, 2/27/15).

While Mrs. Morrison used the app far less frequently than Mr. Grayson, I was still

able to gain insight into her processes because she scheduled each app use so deliberately

that I could observe her as she thought aloud during each use.

Summary of participants' app use. The app was designed with both explicit

and implicit functionality; the teachers used the former but did not recognize the latter.

Explicit functionality. Both teachers engaged with the overt functions—

recording notes about students, surveying students, placing students in small groups.

Mrs. Morrison sampled each tool when its function aligned with a pre-exiting practice;

whereas, Mr. Grayson tried all the tools at once, rejected them, and then returned to an

intensive period of engagement with Survey, and to a lesser extent, GroupMat. (Their

total quick notes, surveys and groups are illustrated in Table 6.) Affirming our

assumption that teachers would use a tool that felt familiar to their general practice, both

Table 6
Total number of items created in app by each user Total number of items created in app by each

User	Quicknotes	Survey	Grouping
Mrs. Morrison	55	6	7
Mr. Grayson	23	31	19

first engaged with the Quick Note tool (i.e., teachers are accustomed to keeping student

records). Mrs. Morrison's persistence with Quick Notes may have been due to the fact

that her workshop model necessitated note-taking during conferences. While neither

teacher had much success with Survey or GroupMat during the unguided phase (i.e.,

because of bugs), Mr. Grayson did attempt to group students using the GroupMat,

"according to various things, ability or whatnot, or interest," but felt that it was not as

easy to use as he would have liked, or he "didn't know how to use it as

effectively" (interview, 12/15).

Both teachers persevered through inconsistent functionality and bugs when they

viewed a tool as crucial to their instruction. Mrs. Morrison persisted with Quick Notes

despite where Mr. Morrison did not, and he fought through issues with the Survey (i.e,

surveys not sending, students responding multiple times) because he came to depend on it

for his World Geography instruction. For Mr. Grayson, who was operating in an almost

crisis situation, the app helped him toggle quickly between interests/topics and groupings.

Once Mrs. Morrison committed to using the app for an established routine, she stuck with

it. Many of her routines already aligned with those of a differentiated classroom, and so

she used the app to reinforce them. Mr. Grayson, who was trying something new, seemed

to let the app lead him.

  Implicit functionality. We also designed the app with more nuanced purposes: 1)

to encourage the systematic study of students, 2) to imply student data should inform

instruction, and 3) to position teachers to provide instructional responses to assessed

student needs. We did not functionally operationalize these intentions, the teachers did

not intuit them.

  Arguably, the teachers did engage in a study of their students, albeit not

systematically in the app. For example, Mr.   Grayson consistently used Survey to

understand how his students were reacting to instruction in the Spring, and Mrs. Morrison

methodically collected data about her students in conferences in the Fall. Generally,

though, the teachers' study of students involved surveying their interests, which they

executed using the survey tool. Mr. Grayson also created and administered a "Getting to

Know You" survey to most of his classes at the beginning of the year (Figure 46). Still,

that data seemed to remain static. Before he started using the app consistently, Mr.

Grayson reported,

> I don't know if it [the app] informed instruction all that much. But at least it got
> me to know my students a little bit better. I was also sort of, from what I learned
> about them, making choices about where they would sit, or who they would sit
> with, or stuff like that. Or the kinds of topics that I might assign them, as opposed
> to different groups, because I knew they were interested in that. I don't think
> there was any sort of [sic] systematic changes I made. But there were things I did,
> I'm sure, some choices I made based on some information I gathered through
> some survey data (interview, 12/14).
> While teachers at least superficially used the app to study students, they showed

less enthusiasm for the second implied purpose of the app—data should inform

Figure 46. Preview of Mr. Grayson's "Getting to Know You" survey, sent to his World Geography class. Screenshot from Mr. Grayson's app account.

instruction. Functionally, the app suggests this by automatically transferring multiple-

choice survey responses into groups on the GroupMat in encourage intentional grouping.

While Mr. Grayson used the auto-group function frequently, transforming interest survey

data into groups, Mrs. Morrison used it sparingly (as she did with the app in general),

only using the auto-group function to rank students' first or second choices. Neither

teacher, however, explicitly used the app to auto-group based on a multiple-choice item

that assessed readiness. In fact, both teachers exclusively used the survey-to-grouping

function to group by interest.

Finally, while the app did position the teachers to respond instructionally to data

they collected, they did not make the final leap to modifying instructional tasks based on

that data. For example, Mr. Grayson used the app to ask students to "[l]ist as many

specific examples of 'movement' in Africa as you can think of." Student responses did,

indeed, exhibit range of background knowledge and depth of understanding on which

readiness differentiation could have been based:

- Movement could entail physical movement of population or movement of

  ideals or politics, examples being the spread of democracy or religion or

  migration throughout African countries.

- Colonialism, Apartheid regime forcing people apart, Chinese treasure voyages

  to Africa, Salt-gold trade routes into the Sub-Saharan regions, Zulu militarism,

  African front in the World Wars.

- Hunting patterns, back-to-africa?

- I dont know what that ius [sic]

- Im not sure [sic] (exit ticket from AdapDif survey, 2/27/15).

Certainly my lack of observation does not mean it did not occur, but neither

teacher seemed to act upon their survey data outside of forming interest groups. For

example, I did not observe Mrs. Morrison using data from her "Writing Interest Survey,"

nor did I find evidence in the app (i.e, in the form of grouped patterns.) I also did not

observe her using formative data at the classrooms level to pre-assess students and form

scaffolded lessons around a learning goal. Again, absence of these data do not mean it

did not happen—Mrs. Morrison's app use was sparse, and so much of her practice was

not captured on it, while Mr. Grayson often did his planning at home.

In short, though, readiness differentiation alluded both teachers, at least as

evidenced in their app use. "Positioning" teachers was not sufficient to nudge them

toward more sophisticated practice, nor was implying that data should inform instruction.

Both teachers, like their students, likely needed scaffold support to better understand how

to make those leaps to modified instruction and, perhaps more important, to understand

how it would improve their instruction.

In phase II of this Capstone, I presented cases of two secondary teachers. I first

fully described their teaching style and instructional contexts to capture the myriad of

variables that add complexity to a simple teacher persona. I then explored how each

teacher integrated AdapDif's app in their classrooms, specifically how it supported their

efforts to modify instruction. Finally, I concluded with the overarching finding that

teachers engaged with the overt functionality of the app but failed to intuit or act out next

steps toward differentiated instruction. In the following section I discuss inferences

based on these findings and synthesized them into this Capstones' second theme.

Theme II: Rebalancing the differentiation ecosystem

The differentiated classroom is an ecosystem whose survival depends upon the interdependent functioning of its elements—learning environment, assessment, curriculum, instruction, and classroom leadership/management. The cases described in Phase II reveal that, despite the awareness and will of two competent teachers, only parts of the differentiation ecosystem thrived (e.g., learning environment), while others intermittently flourished (e.g., high- quality curriculum) and still others lay fallow (e.g., readiness differentiation). While the presence of the app did not refine teachers' differentiation practices, the ways in which teachers used and talked about it revealed potential for these "broken" differentiation systems to be healed—they were fragmented but fixable.

Fragmented. Because the app encouraged some, but not all differentiation practices, it follows that teachers engaged in the parts, but not the whole of differentiation. For example, teachers grouped students frequently, but not flexibly (i.e., they predominantly grouped by one variable, interest). When one teacher did consider readiness (i.e., MAP scores), her instruction still did not vary according to those scores. Similarly, when the other teacher invited students explore big ideas, the tasks lacked scaffolding to help all students access those ideas. These practices—flexible grouping and modified instruction for readiness—are mechanisms that regulate the differentiation ecosystem.

Unsurprisingly, the insertion of the app did not magically transform classrooms into thriving differentiation ecosystems. Teachers used a given feature set (e.g., GroupMat and Survey), with which they developed some fluency, but they did not extend

beyond them. The functions—note-taking, surveying, and grouping—encouraged some

differentiation processes but ultimately did not discourage fragmented differentiation. As

stated in the introduction, we built the app based on the premise that teachers must first

know students in order to reach them, after which they can make instructional decisions

that are targeted, meaningful and engaging. At this point in its development, the app does

not support the second part of that premise—that teachers make targeted instructional

decisions—and teachers did not make that leap on their own. We had hypothesized that

teachers may not maximize practices to modify instruction and would benefit from a

professional development layer in the app to guide that process. This proved to be an

accurate assumption, at least in the contexts studied in this investigation.

Fixable. Had the findings concluded with only the discovery of fragmented

classroom systems and an app that did not propel teachers forward in their practice, the

implications for AdapDif would, perhaps, be fatal. Encouragingly, though, the

conversations generated around app use revealed teachers with promising instincts, a

willingness to learn, and growth mindsets—conditions in which differentiation

ecosystems can be rebalanced. These promising attributes reinforce the contention that

teachers can be inclined toward differentiation, even when they do not accomplish it full.

This is an auspicious finding for AdapDif as we seek to understand potential customers

and convince investors .

Differentiation instincts. Both teachers instinctively understood that classroom-

level data should be gathered, even when they stopped short of acting on it. Mr. Grayson

aspired to know his students as he did early in his teaching career, and he often perused

survey data to work on this. Mrs. Morrison also used Quick Notes to gather data as part

of her more routinized processes. In fact, had Quick Note's functionality been more

refined (e.g., group notes, easy dictation on a mobile interface), both teachers may have

indulged these instincts further. Another instinct they shared was an awareness that they

should act on the data, even though they did not always do so. For example, when Mr.

Grayson deprecatingly said, "We could *actually* use our survey data to inform what we do

on Wednesday," (observation, 2/9/15) his statement implied that I had not yet observed

him doing it, but that he knew he should (and actually could in this instance). Mrs.

Morrison tried to incorporate readiness data collected during student conferences into the

formation of her book clubs. She even demonstrated an awareness of scaffolding by

mentioning a tool that could help a particular student with a difficult book choice. While

her efforts to modify instruction by readiness were not nearly as visible or fluent as her

other methods, she made small attempts. Both teachers lacked something that would

propel them to their next step.

   "There's got to be a better way." Also promising was both teachers' ability to

recognize shortcomings in their current instruction and their comfort in seeking help or

collaboration. For instance, Mr. Grayson verbalized that "kill and drill" was not the most

effective strategy, but his anxiety about the SOL created a dissonance between this

knowledge and his willingness to attempt more conceptual instruction. As he reflected on

his MISSION class, he acknowledged that there must be other instructional alternatives

but implied that he did not know what they were. Mrs. Morrison, too, recognized that her

standard block was more teacher-directed than her advanced class and, toward the end of

the study, considered moving that class to a guided reading model. She said, "The shame

of it is, the standard class tends to be more teacher-directed—not all the time—but it

would be better if it was just scaffolding them to get to the same place" (informal

conversation, 3/17/15). She held her hand to indicate that the "same place" was high, a

suggestion that she intuited the value of teaching up but was not executing it.

Both veteran teachers were also comfortable asking for advice. Mr. Grayson

seemed especially unthreatened by the notion of coaching. He characterized his

collaboration with the division instructional coaches as a "cry for help." He often elicited

my input during classroom observations and jokingly referred to me as a "good

differentiation coach" (observation, 2/4/15; 2/6/15). While Mrs. Morrison did not treat

me as instructional source —more collaborator in app development—she did

occasionally ask for my research perspective on a decision. Like Mr. Grayson, she was

likely to seek support online from sources she deemed credible. For example, she trusted

one in particular (e.g., choiceliterary.com) because, "It's real teachers sharing how they

do things, but they obviously have the expertise in their area" (think aloud, 1/5/15). In

fact, they both seemed to respect credible sources, whether in the form of a training

delivered through UVA, practitioner books by experts in their field, websites from

universities or trusted teachers' Pinterest sites. This instinct to seek trustworthy sources

reinforces AdapDif's plan to provide professional learning in the app.

Willingness to grow. Finally, both teachers demonstrated a growth mindset

toward students and themselves in own practices, a foundational condition for

differentiation to flourish. Despite her deliberate and cautious persona, Mrs. Morrison

was also open to refining her practice. For example, when I asked how long she had been

doing error analysis with students on their exams, she said, "Ten years at this school, and

then … so, 18? And I still don't have it right!" She continued, "I think that when you

stop trying to do something better is when you need to make a change … a new grade, a

new topic ... I see people burn-out at that point and that's when it starts to impact the

kids" (observation, 3/19/15). Evidence of a growth mindset is important as we seek out

users and teacher collaborators. Furthermore, while Mrs. Morrison did not significantly

deepen her differentiation practices, she did advance her technology integration,

suggesting AdapDif was on the right track building easy-to-use tools.

Aside from his growth mindset, Mr. Grayson evidenced *actual* growth as he

incorporated the app into his instruction. For instance, he evolved from having students

count off to form random groups to systematically gathering student interests and

regrouping frequently and accordingly. Over time and , he also shook his discomfort

with allowing students to construct their own understanding of the content. This was

revealed as he reflected on his practice to me during class, initially making statements

like, "Is this an effective way to disseminate information? I'm not sure" (observation,

2/4/15), to saying, "I'm starting to let go about them not getting

something" (observation, 2/9/15) and eventually letting students teach the content to one

another. (All his World Geography students passed the SOL.) Mr. Grayson's growth

accompanied his escalating use, an encouraging finding for AdapDif as it reinforces our

hope that teachers would engage in more complex practices as the app facilitated them.

Finding teachers' next steps. User testing uncovered areas of growth for both

teachers—their ecosystems could come into balance by adjusting some grouping and

assessment practices. For example, because they defaulted to heterogeneous groupings,

both would benefit from training in maximizing engagement in small group tasks.

Complex instruction (Cohen, 1994) is an advanced approach that would appeal to Mrs.

Morrison, while simply assigning group roles could counteract Mr. Grayson's concern

about the imbalances in groups (i.e., he does not like to group high-flyers because "the

others sort of sit around looking at each other, not knowing how to help"; observation,

1/30/15). In fact, Mr. Grayson's students explicitly asked for roles (i.e., in an exit

survey), and Mrs. Morrison requested that the GroupMat have the capability to assign

group roles.

Certainly students would also find group work more engaging if the tasks

challenged them relative to their readiness. Both teachers would benefit from

understanding the nuances of readiness differentiation, such as creating scaffolding

students toward respectful tasks. Although Mrs. Morrison had a more comfortable

relationship with assessment than Mr. Grayson, who often bemoaning his lack of time to

grade (e.g., observations, 3/18/15), her facility did not translate to tasks varied by

readiness. She did offer writing mini-lessons to students, but participation in them

seemed self-selected (e.g., "Look at your Writing Goals that you set for yourself earlier

this year. Which domain did you choose to focus on? Hint: look in your journal.

If you chose Organizing and Elaborating, what steps did you select to reach your goal?").

For Mr. Grayson, assessment for readiness was especially out of his grasp in World

Geography because he did not know the learning progressions. He announced this with

some agony in his voice: "I don't know where I'm going, so I don't have good

assessments" (observation, 2/11/15). As hungry as he was for support, Mr. Grayson

would surely benefit from a feature that outlined learning goals for his unfamiliar content

area, provided survey items that correlate to the goals, and made suggestions for

differentiated tasks. The fact the both teachers have obvious next steps in their

differentiation practice is a positive finding for AdapDif and can inform *our* next steps.

Theme II Conclusion. Ecological restoration suggests that any ecosystem is

fixable. These two differentiation ecosystems were unbalanced, and the app alone and in

its nascent state, did not nourish the ecosystem enough to recalibrate it. Still, the findings

simmer with an undercurrent of optimism that the teachers can be nudged toward more

fully realized differentiation practices (a boon for AdapDif as we contemplate the wisdom

of continuing with our development). In fact, this theme suggests that a more fully

developed app could contribute to a more fully realized ecosystem, nurtured by a willing

and reflective teacher .

Theme III: Differentiation as a Grand Problem

Theme I captured the big idea of development, the misalignment of purpose and

process, and Theme II revealed the promise of a more completely developed version of

the app to ameliorate an unbalanced ecosystem. While AdapDif was bombarded with

endless business platitudes masquerading as advice, during data analysis, two ideas,

jotted hastily in Evernote, suddenly leapt from the page: 1) Software is designed to solve

a grand problem, broken into smaller problems, that are solved by features, and 2) all

software is developed to solve perceived problems of time and complexity. In this final

theme, I applied these two ideas to the differentiation problem, providing deeper insights

that might lead to a more sophisticated solution.

Our Grand Problem. The first contention, "Software is designed to solve a

grand problem, broken into smaller problems, that are solved by features," does, indeed,

align with AdapDif's development process described in Phase I of the Findings. Stripped

almost to a state of oversimplification, AdapDif's grand problem was, "Differentiation is

challenging." In trying to address that problem, we brainstormed solutions to a series of

smaller problems. In the Literature Review, I characterized these problems as possible

"impediments to successful differentiation," although we did not delineate them

systematically during development. Some of these problems were research-based (e.g.,

data literacy, teacher beliefs/rejecting practices, content/pedagogical content knowledge)

while others were teacher-based (i.e, the demand for tools and strategies).

We did, then, attempt to solve these problems with features. Our mentoring (i.e.,

with Venture Design) reinforced this process by encouraging us to move from personas

and user stories/problems to features. As a result, in Development Stage I, we built an

app with features for note-taking (e.g., Quick Note), surveying, (e.g., Survey), and

grouping (e.g.,) in response to the perceived teacher need for tools. In Development

Stage II we proposed to solve the research-based problems by embedding a professional

learning layer, which we assumed might feature training modules or videos. We did not

envision features to address the complexity of Stage III. Figure 47 reshapes the data and
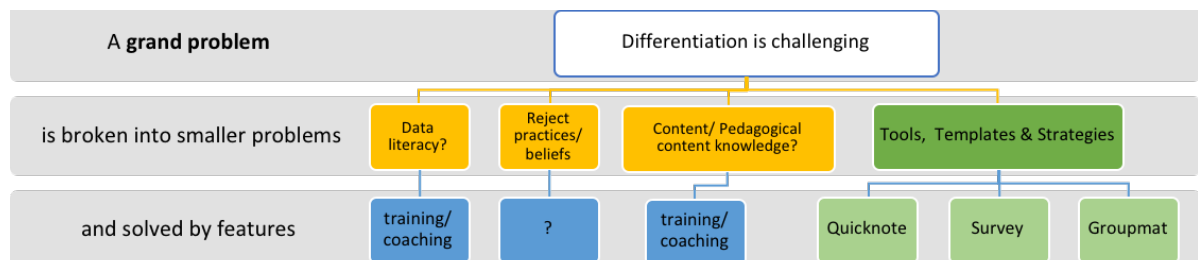
Figure 47. The grand problem of differentiation broken into smaller problems (i.e., impediments to differentiation) and solved by features (i.e., hypothetical and in the app.)

visually captures differentiation as a grand problem that can be broken into smaller

problems, that can, in turn, be addressed or solved by features.

Unfortunately, conceptualizing the problem like a software designer, reduces a

complex problem to a set of discrete problems with the expectation that they can be fixed

by a feature. In doing so, the solution becomes fragmented, and, in our case, that

fragmentation easily manifests into a set of tools. Ironically, this fragmentation actually

appeals to educators (i.e, for teachers, a set of tools; for administrator, a checklist of items

to look for on a walkthrough). When educators conceptualize the problem as fragmented,

and the solutions as fragmented, they naturally gravitate to a toolbox of decontextualized

strategies. However, those tools become meaningless without a deep understanding of

how they feed and support the ecosystem of the differentiated classroom.

"Time" and Complexity. AdapDif's problem of practice hinges on the key

question, "How do we practically reconcile the teacher desire for practical supports the

research-supported conclusion that teachers would benefit from deeper knowledge?" If,

in fact, all software is developed to solve problems of *time* and *complexity*, that question

might be better answered when considered through those lenses.

Time. Based on the common refrains from teachers that they "don't have time" to differentiate and want tools that are "easy to use," AdapDif's initial solutions, not unreasonably, reduced the problem to time*.* For example, our first attempt at describing the problem for the Curry Cup read,

> Teachers are under a significant time pressure to constantly increase the learning outcomes in their schools while dealing with students' varied levels of readiness, flagging motivation, complex preferences for learning…[T]he majority of them point out, rightly, that the process of providing differentiated instruction requires a significant amount of time (Concept Proposal, 11/2/13)

 Phase II revealed that time, while obviously a legitimate concern as a limited commodity, may be a proxy for other issues.

"Knowing" students. AdapDif actualized the "ASK" step and built features that allowed teachers to have a systematic way to collect data to better know their students. Mr. Grayson reinforced this premise, articulating a common concern voiced by secondary teachers:

> With 130 students, knowing your students becomes problematic, then going back and looking at [data]? … Am I really going to go back and look at it when I have to jam up some lesson, for the 4th lesson that I have to look at that day. It is different than elementary when you get to cater to their needs. If I taught one thing six times, I could spend more energy knowing my students better. For me, it's how am I going to present this content for the greatest good for the greatest number" (observation, 1/30/15).

For Mr. Grayson "knowing my students better" not only means connecting with them in person, but also knowing where they are relative to a pre- or formative assessment item. His perception of time equates to reviewing data and then making instructional adjustments based on that data.

Planning. When I directly asked Mrs. Morrison if time was an impediment to differentiation, as it seems to be for many teachers, she said that time, for her, is about planning. Her issue with differentiation was about "feeling like she has to plan for something different every time." She elaborated, "If it's not something I feel like I can fit into my routine, that it is something separate, that's what it is for me" (observation, 2/10/15). In another instance, after demonstrating how to create different sets of directions for each group in the app, she was pleased by how much time it would save her. Time, for her, was about not upending her routines but making them run more efficiently.

Cover Content. Mr. Grayson also struggled with planning time, specifically, to "think through" the content. In class he often expressed his concern about where a lesson or unit was going, and he would often mutter that he needed more time to think. Time also concerned Mr. Grayson as he constantly fought against the perceived demands of the SOL. Although he never uttered a common teacher phrase, "covering content," it was implied (i.e., '"We still have to get to the other side of the world"; "The SOL is a list of things. At some point I need to give them a list of things to memorize") (observation, 1/30/15). Mr. Grayson needed time to understand his content well enough to distill it and create impactful learning experiences.

Assessment. Both teachers expressed irritation about the time it took to grade. Mrs. Morrison hated grading homework and built elaborate processes to avoid having to do it herself. Classes often began with students in homework triads, working through the previous night's homework while she walked around with a clipboard, checking to see if

they had completed it. She also spend a great deal of time grading formative assessment

or journals. Mr. Grayson would squeeze grading papers into any free moment he had,

and he mentioned he liked Blackboard because "one person from a group can turn in the

group assignment, and I can give it a grade directly" (observation, 3/11/15). Time to

grade plagued him, and he would call out things like, "I am going to get to grading

things, people, some day" (3/18/15). As is a common teacher complaint, his perception

of time translated to time to grade.

  Conclusion. Time is a particular pain-point for teachers, the control of which is so

often out of their hands. Mr. Grayson was constantly being pulled into meetings that

were "not worth it" (observation, 2/25/15), and both were interrupted by holiday

schedules (e..g, Valentines Day) or unpredictable snow days. As a result, both teachers

carefully monitored classroom time. For Mrs. Morrison, classroom time was structured

and the pacing clearly announced. She planned methodically and used time

"wisely" (i.e., careful about group configurations, methodical about feedback and

assessment). Even the more chaotic Mr. Grayson projected internet timers during group

work and checked in with students to ask how much time they thought they needed to

complete a task.

  When they do have control of their time, it becomes a precious commodity. Any

intrusion into that time had better not waste it and had better add value. In fact, both

teachers stopped using the app during the unguided phase because of "time." Mr.

Grayson abandoned the app because onboarding involved too many steps, software bugs

caused him to lose data, and, ultimately, other systems already in his workflow ate less

time. Mrs. Morrison stopped using the app in October because of time, as well: "It was a time thing, because my student teacher had taken over. So, I figured let it ride at that point. Our schedule was pretty tight in the fall with what we get done. So, I thought probably in January, I'd probably use it" (interview, 12/14).

In trying to turn a problem of practice into a viable solution, it becomes more important to understand what teachers mean when they complain about time. The time burdens they expressed in this study—to know all their students, to cover standards, to plan more than one lesson, to assess students—might actually translate to burdens of complexity.

Complexity. The findings suggest that the problems of time are actually problems of complexity, and these map to the challenges inherent in understanding differentiation. This is illustrated when "smaller" problems embedded in the grand problem of differentiation are recategorized under the headings of time and complexity (Figure 45). When differentiation is perceived as a challenge of complexity (shown in the right column of Figure 48), the sub-problems align with those that researchers and educational experts identify,

- reviewing data and then making instructional adjustments based on that data (i.e., pedagogical data literacy),
- understanding content well enough to distill it and create impactful learning experiences (i.e., content/pedagogical content knowledge)
- knowing how to teach up and design scaffolded, respectful tasks, (i.e., understanding the complexity of differentiation)
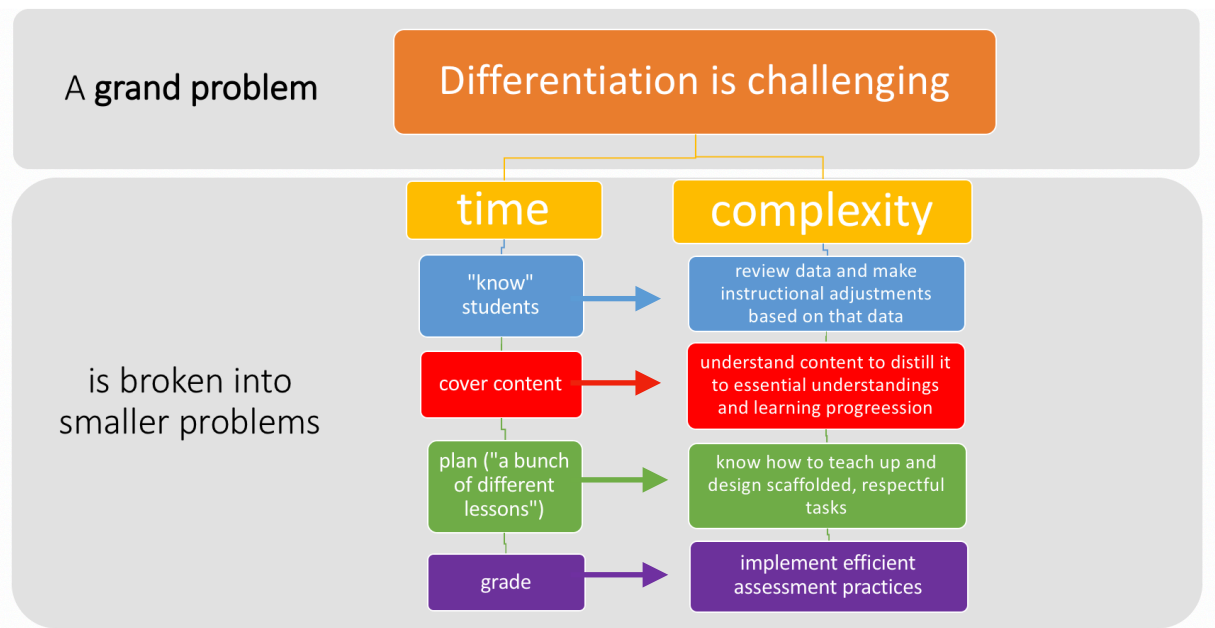
Figure 48. Differentiation as a grand problem broken into the problems of time and complexity

- implementing efficient assessment practices (i.e., understand assessment

  practices/teacher beliefs.)

 Teachers' general complaint of "time" (in the left column) not only breaks down in

proxy problems (i.e, "knowing" students, planning, delivering content and assessment)

which, in turn, correspond to problems of complexity. For example, Mr. Grayson's

seemingly insurmountable time problem of of "knowing" so many students is really

about the complexity of having to make sense of data collected about them. The problem

of too little time to cover content for a standardized test or to think through content may

really be about understanding a discipline well enough to distill it and translate it into

meaningful learning experiences. Believing there is not enough time to plan multiple

lessons, suggests a misconception about differentiation or a lack of knowledge about how

to create meaningful, scaffolded tasks. Finally, grading is always a labor-intensive

endeavor, but the time burden can be attenuated by more informed assessment practices.

The "smaller'" problems embedded in understating (e.g., data, content, and

pedagogical literacy, teacher beliefs) are far too complex to reduce to a feature. These

problems are not solvable when thinking in terms of feature/function—the solution is not

in *where* teachers collect their notes (e.g., Evernote, Google Docs, Word) or *how* they

survey students (e.g., Google Forms, Polls Everywhere, Socrative). While these tools

leverage technology to alleviate some of the superficial burdens of time, they do not

solve the complexity. The solution is in connecting the *how-to* with the *why*.

The AdapDif solution must address "time" in its manifold meanings to teachers

and the complexity inherent in the model, the classroom, the teacher, and the student.

The solution must both must alleviate the perceptions time and simplify that which seems

complex. It must match complexity of the model, the teachers, and the students. The

solution has to be, in the words of Tomlinson, "developmental and idiosyncratic like the

teachers" (personal communication, 4/15).   According to a message found in the

whiteboard jungle of our development data, AdapDif recognized this from the beginning:

"Design such that TEACHERS BELIEVE ENTERING THIS DATA WILL MAKE LIFE

EASIER AND TEACHING BETTER" (Figure 49).

Theme III Conclusion. As a company seeking to satisfy a customer, AdapDif

cannot dismiss a teacher's perception that time is their problem. As a developer of a

product in search of a market, the customer's perception is, to a certain extent, truth. The
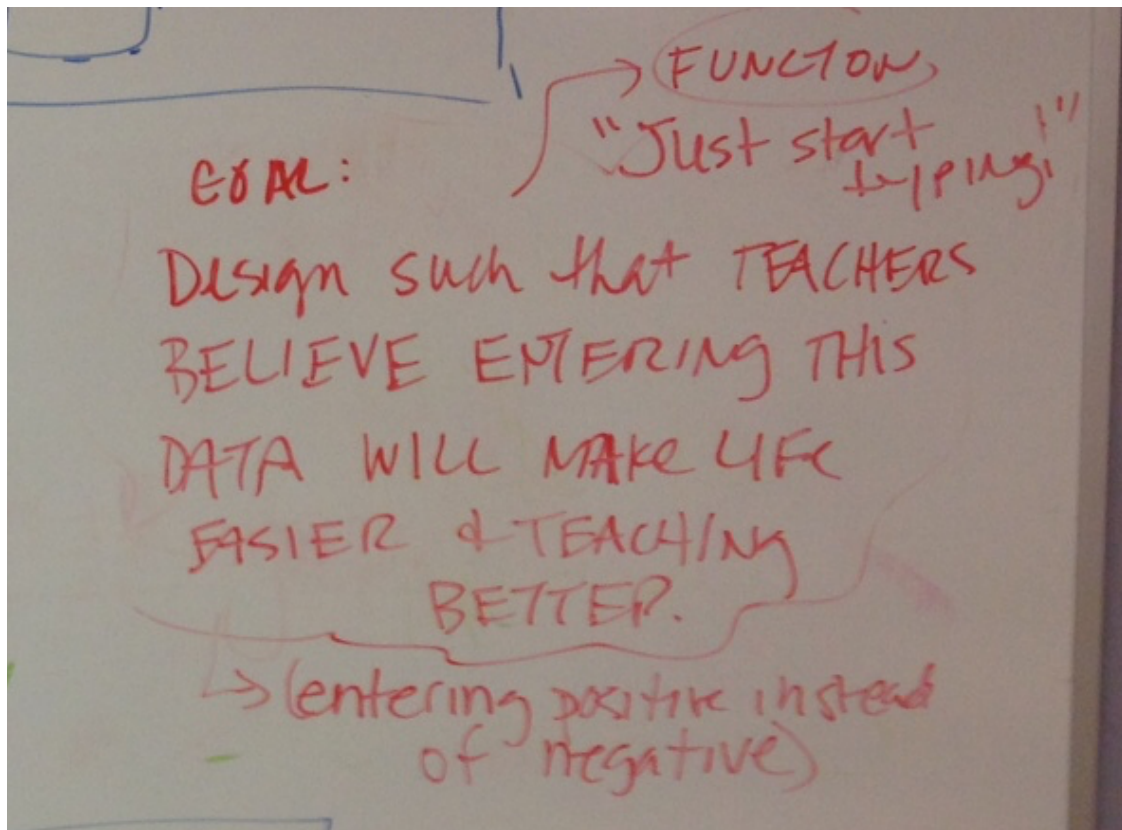
Figure 49. AdapDif's stated the goal, "Design such that TEACHERS BELIEVE
ENTERING THIS DATA WILL MAKE LIFE EASIER AND TEACHING
BETTER." Whiteboard, 6/10/15

iLab emphasized the centrality of the customer, or at least the importance of addressing

their perceived needs (which translates into a potential market).

One must understand what they believe to be their stumbling blocks in order to

meet them where they are and nudge them forward. Researchers (Sherman, 2009)

explain teachers relationship to time thusly:

> When results are not immediately apparent, teachers may move on to the next
> workshop idea, often leaving what is a valuable educational idea in the dust. The
> desire to find a quick fix that is not time and labor intensive is understandable,
> especially given the lack of resources and increasing diversity of public schools
> coupled with the demand for accountability and the implementation of unfunded
> mandates" (p. 57).

For the AdapDif team, it is equally, if not more important, to decode their beliefs about time and understand them as issues of complexity—that which seems complex or hard to understand elicits fear. When one simplifies complexity, or make solutions more accessible, one attenuates that fear.   Solving complexity, saves time.

Conclusions from Findings

In the introduction to this Capstone, I promised that this investigation would "shed light on the complex process of creating a research-based, educational application impacted by the business imperatives of a start-up Incubator." Examining both development and testing revealed that AdapDif arrived at an unfinished solution that only begins to address the problem of practice, but one with potential.

Phase I. The iLab exposed us to processes, some helpful, others not less so, that impacted our development direction. Each moment of dissonance subtly redirected our thinking, focus, and resources toward a fragmented and incomplete solution. AdapDif articulated what we would call our problem of practice and what the iLab would call an opportunity. For us the "opportunity" to improve education, to capitalize on the affordances technology could improve learning for students by helping teachers improve their processes. But for the iLab, the opportunity was for investors to make money through problem with a high-risk/high reward solution—not an inherently bad process, just one ill-suited to solving a problem of practice for the classroom.

The iLab processes encouraged the oversimplification of a complex problem of practice. The rush to build an MVP lead to a lack of confidence and certainly about the

solution; the Venture Design processes stemmed from a software paradigm in which a

complex problem is reduced to an isolated in a series of features. When the investors

who may fund your solution demand to first to see successful pieces of the solution, you

take your limited funds and build those fragments. When that fragmented solution

appeals to the potential customer (i.e., tools or one day PD with strategies), the process

reinforces itself. Before you know it, you have built a solution that reinforce the

fragmentation, potentially pleases the customer but does not really solve the initial,

complex problem.

Phase II. User testing revealed that teachers would, in fact, engage with the tools

as designed and fold them into their workflow. Further, they desire support implementing

differentiation and would benefit from an deeper understanding of its principles and

philosophy.

AdapDif's presence in the classroom did affect the teacher's instruction,

triggering both collaboration (i.e., with me) and reflection on their practices. The extent

to which the app caused those changes is unclear. At one point Mr. Grayson observed

about intentional grouping, " I'm thinking about it because I'm using the app. I don't

always group by interest" (1/30/15).

"I'm trying to get better at using the app and thinking about grouping. My brain isn't

exactly wired for it" (2/9/15). He also said, "Your presence makes me think about

me" (1/30/15).

attributed the changes in his teaching to our interactions or the app, Mr. Grayson

concluded, "I would say all of the above. I had to have some context for differentiation.

It's a combination of the technology with the coaching that will make the difference. I

don't think technology alone, for me, where I was in my knowledge, was going to change

the way I taught" (informal interview, 4/8/18).

Next steps would look different for each teacher, although they would both end up

on some of the same learning pathways, most notably, toward readiness differentiation.

The teachers in this study did not take these next steps on their own. The app, though,

was an incomplete solution—we recognized this. Our platform was "neutral" because it

offered tools for the *what*, and not only did not provide the *how* layer, but, most

convincingly, the *why*.

CHAPTER THREE

Implications, Recommendations, Actions & Limitations

In this study, I examined a solution to the problem of practice: that teachers

struggle to deeply understand differentiation and—perhaps, consequently—to skillfully

implement it. The findings discussed in the previous chapter have implications for

AdapDif, and these implications naturally lead to a set of recommendations for our future

development plans. While the implications and resultant recommendations relate

specifically to AdapDif's context, they may be instructive for others who are also

exploring this problem of practice and who are similarly seeking solutions in educational

technology. In the following section, I have aligned conclusions from the study to

implications, recommendations and, finally, actions for AdapDif.

Conclusion #1: An unfinished solution

In its current state, the AdapDif app presents an incomplete solution and only

begins to address the problem of practice. While the app's tools melded with the study

participants' workflow (as was our intention), the app did not prompt teachers to question

how they were using them, nor did it encourage teachers to move beyond the tools' basic

functionality. In sum, the app alone did not "conjure" meaningful differentiation in their

classrooms.

Implications. This conclusion suggests that discrete tools that support only some

differentiation processes (e.g., flexible grouping, ongoing assessment) will not lead

teachers to enact differentiation holistically. A solution to the problem of practice,

therefore, cannot be found in a single tool or even a set of tools.

   Recommendations/Actions. AdapDif needs to adjust our solution to mirror the

ecosystem we want teachers to create—one that is flexible, integrated, instructive,

responsive, and encourages teacher growth. The AdapDif team needs to refine or expand

the Connected Differentiation Model (p. 9), for example, by analyzing the extent to

which the online application alone can support the desired ecosystem and determine what

role human interaction should play.

   Actions. After user testing ended, the AdapDif team mapped out a "solution" to

the problem of practice (pictured in Figure 50, a sketch on a whiteboard) that

incorporated various elements that seemed crucial to teacher success during testing (and

which bore themselves out in this study):

- content for teachers (i.e, exemplars for lesson plans, learning activities, and
  how to translate standards to KUDs),

- teaching tools (i.e., that support grouping, note-taking, surveying, and applets
  suggested by the study participants and that were shelved for lack of time in
  the iLab),

- feedback or "data" (i.e., relative to learning goals, observed student behavior,
  and teacher behavior recorded relative to app use, all able to be interpreted by
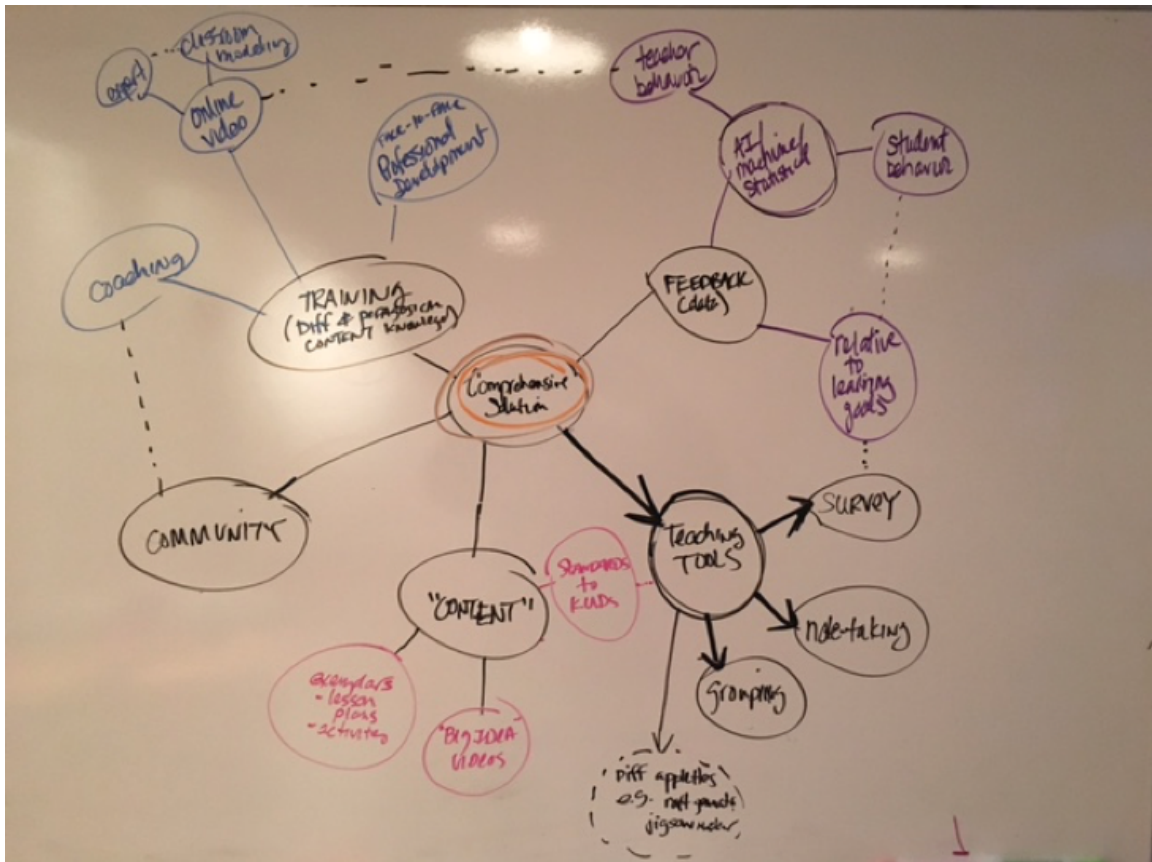 the AdapDif system),

Figure 50. A grand solution to a grand problem: AdapDif's "comprehensive solution"
to the challenge of differentiation. Evernote, 5/10/15.

- teaching training (i.e., face-to-face professional development, online videos

   —featuring both experts and classroom modeling, some form of coaching,

   and

- community (i.e., to meet teachers' need to collaborate).

The team should revisit this map to evaluate the feasibility of operationalizing each of

these elements and prioritize them in a development plan.

Conclusion #2: Diverse teachers

All teachers, like students, have a discernible "next step" in their learning. Both

participants in this study were located in different places on various continua of expertise

(e,g., understanding of differentiation, pedagogical content knowledge, comfort with

technology integration). As a result, both had interacted with the app differently and

required different support from AdapDif and at different times.

Implications. To account for teachers' diverse needs, the app must be structured

allow users to enter and interact with the system flexibly while still guiding them step-

wise through their own learning paths. While the movement through the app is a matter

of UX design, learning paths would require AdapDif to map learning progressions

relative to the principles and practices of differentiation and identify potential teacher

misconceptions along those pathways.

Recommendations/Actions. The AdapDif platform was, in fact, deliberately

designed so that users could access differentiation through tools that appealed to them

and/or integrated with their pre-existing practices. AdapDif should not abandon this

flexible design and should, further, revisit the app to ensure that it is usable across

devices and browsers. More important—and complex—is the recommendation that the

AdapDif team add to the platform robust and structured support for teachers to better

understand and apply meaningful differentiation in their classrooms.

Actions. AdapDif had already planned to embed a "professional development

layer" in Stage II of the development plan. In fact, we now need to refine this plan to

account for its complexity and nuance. For example, we must map learning progressions

for each of the practices of differentiation, which would, in turn, inform scaffolded

learning experiences for teachers as they interact with the app. But beyond these learning

progressions (if they can be determined), we should brainstorm about how the principles

and philosophy can be embedded into other features of the app. For example, Phase I of

the study uncovered an idea for a banner on the app's homepage that displays rotating

quotes supporting a growth mindset. Suggestions such as this should be mined from the

company notes and used as a springboard for other innovations. The AdapDif team

should collaborate with differentiation experts in this process to insure the validity of the

progressions and help unpack the reticular nature of the relationships in the ecosystem.

The AdapDif team should also investigate the technology undergirding

personalization tools (i.e., cognitive tutors) as they use learning progressions in their

products. We should remain cautious, however, about the limitations of such technology,

understanding the danger in reducing learning to a hierarchy of skills. Just as plugging

students into cognitive tutors will not do the work of meaningful, engaging instruction or

replace socially constructed learning, nor will it for teachers. Still, it is worth

investigating how the technology behind "personalized" software might play a role in the

building of the AdapDif system as a whole.

Conclusion #3: Coaching and collaboration

The study revealed the importance of coaching and collaboration. For example,

while using the app seemed to influence teachers' instruction, it is unclear whether the

impact was attributable to the app itself or to the AdapDif support person in the

classroom. Our presence seemed to allow teachers to reflect on their practice (i.e.,

talking aloud to me) and also encouraged them to experiment instructionally with the

support of a knowledgeable "assistant" and collaborator. In fact, both teachers sought

collaboration from others—coaches, co-teachers, teammates, and AdapDif—who they

viewed as credible, while they bristled at unsolicited intrusions.

Implications. Teachers will benefit from active support, both instructionally and

with tech integration, that allows for reflection, collaboration and coaching. This may not

be solved by technology alone. AdapDif's solution should also capitalize on the

collaborative instincts of teachers and support collaborative processes. These processes

should be authentic and involve a credible partner or resource.

Recommendations/Actions. AdapDif should consider the role of coaching in the

solution—and whether it can be delivered in the app—or if the company should consider

integrating coaching in a different way. We should also extend this lesson about

collaboration to development. Instead of entering the classroom as external problem-

solvers, AdapDif should invite teachers into the development process, and perhaps the

company itself. Approaching users as partners aligns more with AdapDif's goals and

belief system than does entering their teachers' space as external experts. By working at

greater length and depth with teachers, AdapDif can be clearer about the teachers needs

and concurrently "live our beliefs" as a company that puts the teacher before the

software.

Actions. AdapDif should approach the pilot teachers and other former testers for

a collaborative meeting. The study participants took their role as software testers

seriously (i.e., reporting issues, being patient with glitches) and provided smart ideas for

feature and functions (See Appendix O). Mrs. Morrison acted as a partner in the

evolution of the app, while Mr. Grayson acted as a partner in differentiating instruction.

Involve them.

Conclusion #4: Nudge, don't shove

Theme II suggested that teachers had both growth mindsets and demonstrated

some growth in their instruction. Still, their progress was not dramatic. Teachers were,

in fact, open to altering their practice, but in small steps and in ways that integrated with

at least some element of their current practice.

Implication. Solutions must preserve a teacher's sense of autonomy while still

guiding him or her in the "right" direction. In short, we must nudge, not shove, teachers

toward better practices.

Recommendations/Actions: AdapDif must evolve its app beyond being a neutral

platform that merely houses tools and training. The fully fleshed out platform must

interact with users in ways that nudge them toward new behaviors.

Actions. AdapDif should take concrete steps toward building out functions that

move teachers forward teachers and provide them with *just-in-time* support. Concretely,

we should wireframe what these step might look like, starting with basic functions (i.e.,

statistical information about teachers' use patterns—who they are taking notes on or who

they have met with) and becoming more complex (i.e., leveraging the affordances of

just-in-time and adaptive technology to locate the "next-steps" for each teacher and

nudging them toward it).

This final implication was one of the most compelling in the study. Both teachers

were secondary veterans, a notoriously intransigent demographic for change toward

differentiation. Yet, not only were the study teachers open to nudging, they often

articulated how they thought the software could do that. For example, Mrs. Morrison

offered, "I feel like you should be introduced to a new feature every couple of weeks.

Like it could tell you, 'It's been two weeks, and you've used this. You might try this and

here's how you do it'" (interview, 12/14). Interestingly, her idea aligned with AdapDif's

development plan (Stage III) in which the system would offer the user suggestions.

While she couched hers in terms of features, AdapDif based the suggestion in pedagogy.

"You've made some groups. How are you keeping them flexible? Here is a short video

about flexible grouping; You've used these templates (tagged as interest)—now you

might try readiness. Here's a video about learning goals …" (Wireframe, 8/29/`3). Mr.

Grayson, too, imagined a system that would give him suggestions about differentiation:

> Like, "Hey, this is an interesting kind of question to ask when making groups, if
> you're looking for readiness." Or give me ideas of the type of questions I might
> want to ask which might spur my own thinking about the type of questions that I
> may create. I think that can be really useful.   I have done a conference about
> differentiation, but if I don't continually kind of think about it, I won't think
> about it all that much. I think the tool can help me think about it
> more" (interview, 12/14)

    In the end, Mrs. Morrison was more cautious and harder to nudge from her

routines. Three years later, however, she reports that she now does most things in Google

Classroom and emailed a photo (Figure 51) to show her current technology configuration:

computer at the front of the room on a standing desk, document camera still at the ready.

She also reports, "I'm trying to get a wireless connection for the projector, so I can move

around the room with my laptop.[email, 3/16/18]

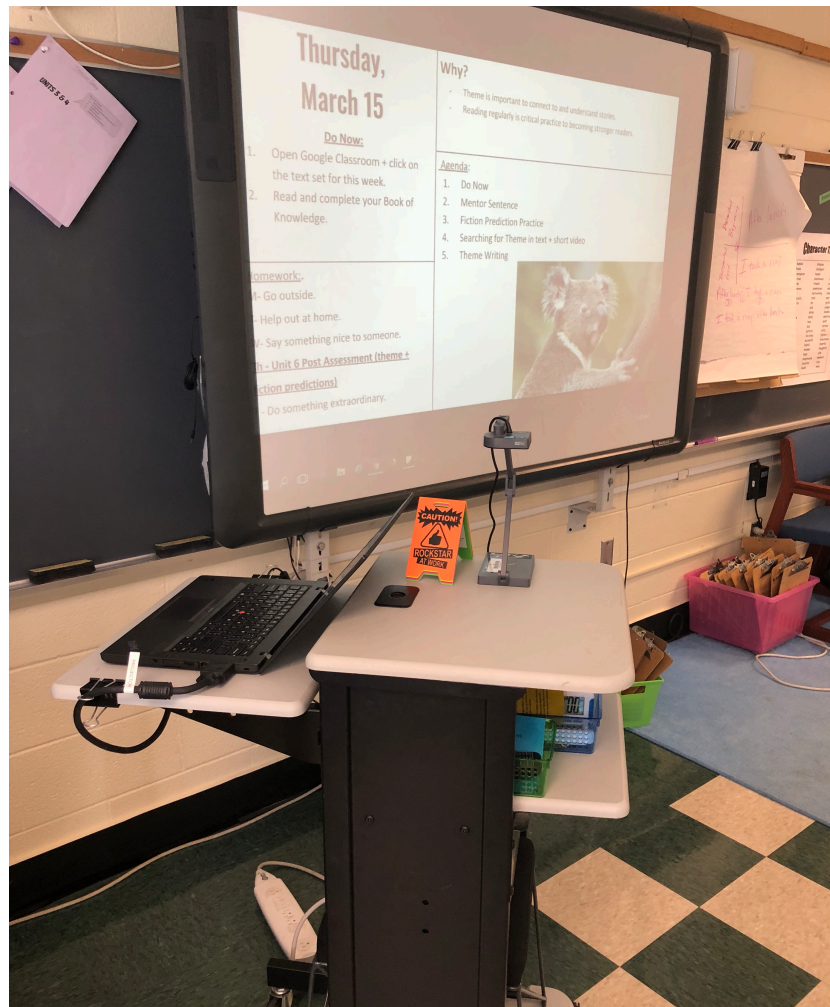**Conclusion #7: Steadfast in the "why"**

Figure 51. Mrs. Morrisons current technology set up. 3/16/18.

AdapDif's goal was to to build a research-based software with a pedagogical

mission, and this study revealed tensions in trying to accomplish this goal in a start-up

incubator. In trying to follow the business processes taught in the iLab, we rushed to a

simple solution to a complex educational problem and, as a result, only addressed a

fraction of it. The app supported teachers in some of the "whats" of differentiation (i.e.,

grouping, taking notes, surveying) and only implied the "hows" (i.e., find patterns in

survey data and group them). Ultimately, we did not provide the "whys" for the teachers,

nor did we articulate it for ourselves.

Implications. As solutions from the business world continue to infiltrate

education (i.e., most recently personalization "solutions" or edtech tools that promise to

differentiate instruction), educational leaders need to be vigilant about the inherent

misalignment of purpose and process. In this study, I presented a microcosm of the

issues that arise when a business-oriented process intersects with an educational problem.

In education we seek to solve problems of practice, and, for an edtech company, the

"opportunity" should be an educational one. In our case, the opportunity was that online

technology could improve learning for students by helping teachers improve their

processes. For investors, however, the opportunity is to maximize profits by investing in

a high-risk/high reward solution to a problem in the market. An educational company

working in the K-12 market, then, must be clear and steadfast in its mission—it's *why*—

in order to navigate the ethical complexities that arise from the intersection of business

and education.

Recommendations. AdapDif needs to reaffirm our vision. Future development

decisions should then emanate, not from the *what* or the *how*, but from a clearly

articulated *why*. AdapDif needs to lead with the why and design functionality that

embodies the it. Furthermore, AdapDif's vision needs to become the teachers' vision, as

well. The teachers not only need facility with the how-to's of differentiation, but also,

more importantly, to understand and embrace they so that they become a meaningful part

of their philosophy and practice. In its current condition, the app is not a robust enough

reason to compel the AdapDif team—or our users—out of bed in the morning; however, the rightness of the mission and the challenging, complexity of the problem are.

Actions. AdapDif's first order of business should be to rearticulate the why as our company mission. Following that discussion, we should revamp development plans and align each step with the why. This alignment should occur in concert with the analysis of the "Comprehensive Solution" white boarded in Figure 50. If we can articulate the why behind each element, we will be better equipped to communicate it to teachers and embed it in the redesign of the app.

From that why, we will able to draft a thoughtful development process and a plan to seek financial resources by weighing the risks and limitations of funding choices and their concomitant processes. We should create a proposal for organizations that might be amendable to a partnership, specifically those with professional expertise that could be integrated into the application. We should seek partnerships with people who understand the iterative processes educational environments demand and have step-wise view of development. We might also consider a professional group that has a stake in the idea of differentiation and is willing to move toward more innovate ways to support it in the market.

Finally, while the AdapDif team initially believed that we were building the app to be *the* viable differentiation solution, we might, instead, view it for what it was—simply a minimum viable product. Despite the requests from iLab and potential investors to "throw it into the marketplace and see what happens" (Evernote, 4/15/15), the app, in this incarnation, was not the sellable solution. We need to recognize that limitation and return

to the belief, affirmed in this study, that a comprehensive solution that supports and

reflects the ecosystem of differentiation is the sellable solution. We need to return to a

grand solution to a grand problem.

Limitations

The limitations that had the most potential to impact the quality of my findings

are listed below.

- The data sample in this study was limited to two teachers, and though it is a
qualitative study and does not seek generalizability, the inferences were limited to
their contexts. I selected participants based on their expressed interest to better
understanding and apply differentiation to their classrooms. The participants also
had high levels of content expertise and a willingness to engage with the app. The
information-rich cases they provided were also specific to the variables of their
"personas." As the app improves, future testing should expand to teachers in
different contexts with different levels of experience and expertise.

- While this study was not an ethnography, to provide more credibility, it would
have benefitted from being more immersive. I could have understood the teachers
better had I observed their instruction with more depth across contexts. I could
have also developed greater insights observing instructional blocks every day that
they met, versus weekly or sporadically over time.

- Time passed between data collection and analysis, and, despite keeping a
methodological journal and inserting analytical notes during observations, the
opportunity was lost for immediate reflection from users or clarification about
their instructional choices. In future research, it would be important to react to the
data more immediately through follow-up interviews conducted closer to data
collection.

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Appendix A

Data Source Examples from Phase I

Meeting Notes examples

Notes from meeting with technology company founder (Evernote, 5/13/13)

Labour intensive on digital as well.
Dictating is unnatural for most people, they need to think about what they want. Mentally very taxing. Typing is good because you revise as you go.
- How to capture with a tablet for instance? (this could be a barrier to entry). User interface would be a primary challenge.
- Tap and click to bucketize the student.
- How would the teachers actually enter the data?
- Amplify startup. Building a custom android based tablet for students and educators. Baron may arrange us to meet people from there, based in New York.

Tips:
- don't be afraid of angel and VC investment, just make sure you have good mentors and lawyers so you won't get screwed.
- don't get angel or VC investment too early. You need to prepare to go to them. Already having some experience with potential target and customer is important.
- there are several risks with the adoption of our technology, think about how to derisk. Especially about how the data entry will happen. The analysis of data is not really relevant if you can't get teachers to somehow enter this data.
- Find another technical person for pure product development. Give him shares for about 15% or more if you need to. Make sure this person is older (late 20s, early 30s) and will work for little money but will have ownership.
- Outsourcing abroad may not be a good idea, make sure when you do there is no time zone difference.
- Getting interns and young programmers will end up with sloppy work and may not be work while. It depends on what kind of people.
 - This is a better book than Lean Startup: Running Lean, (http://www.amazon.com/ Running-Lean-Iterate-Works-OReilly/dp/1449305172).

Parent Portal, "What is Differentiation": Quotes from AdapDif company file from a teacher talking about differentiation. (Evernote, 9/18/13)

Teachers want parents to understand what they are doing.   A series of PD videos for them would be very helpful to teachers.

"What is interesting to me is that the term "differentiation" is not a common knowledge term for those not currently teaching or in academia or college-level education courses. I am just realizing this as I discuss with various, well-educated adults the concept of differentiation and they have never heard the word. While the concept can be understood without having the word attached, having a common "lingo" so to speak is helpful. In my opinion, this speaks to the need for broadening education to not only teachers, but to parents as well." *Kindergarten teacher*

Photo of whiteboard after brainstorming of product development.
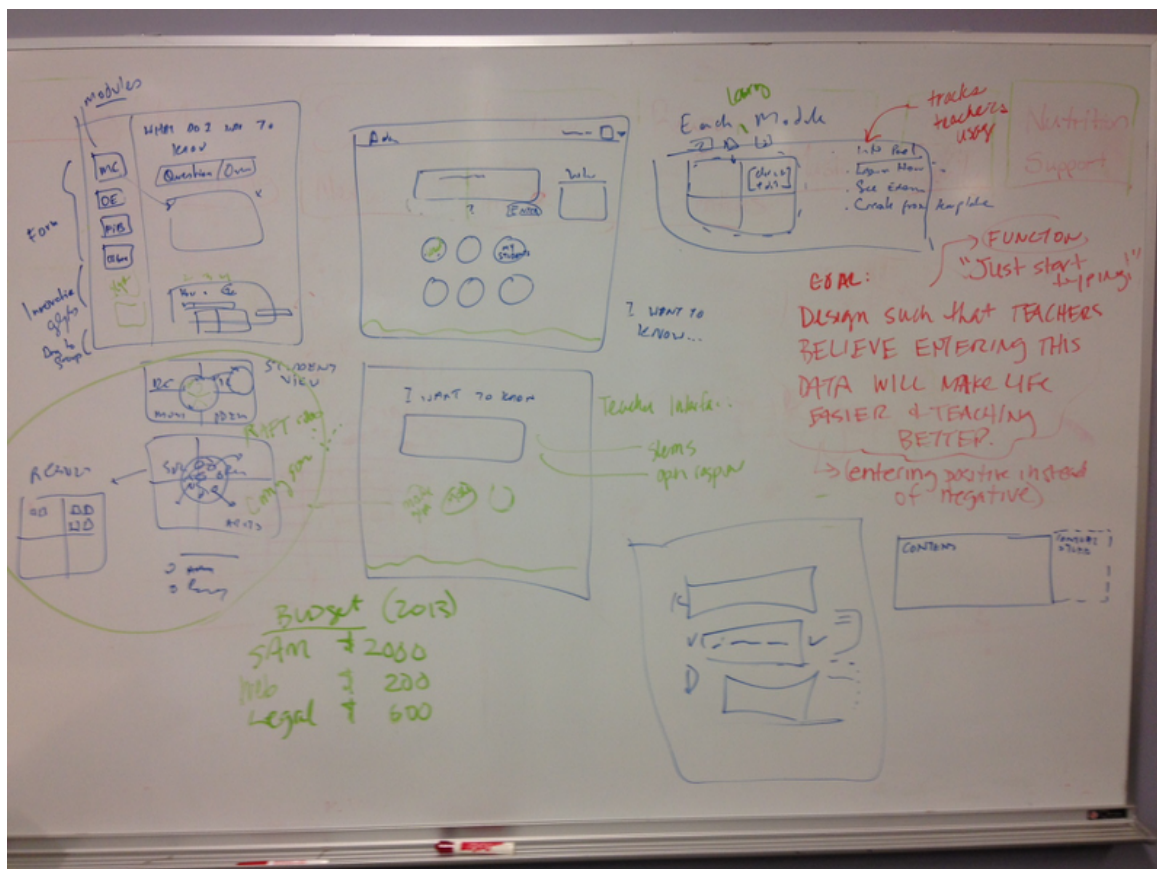
Examples of Wireframes

Idea for homepage design, screenshot (Balsamiq Mock-Ups, 2/16/14).
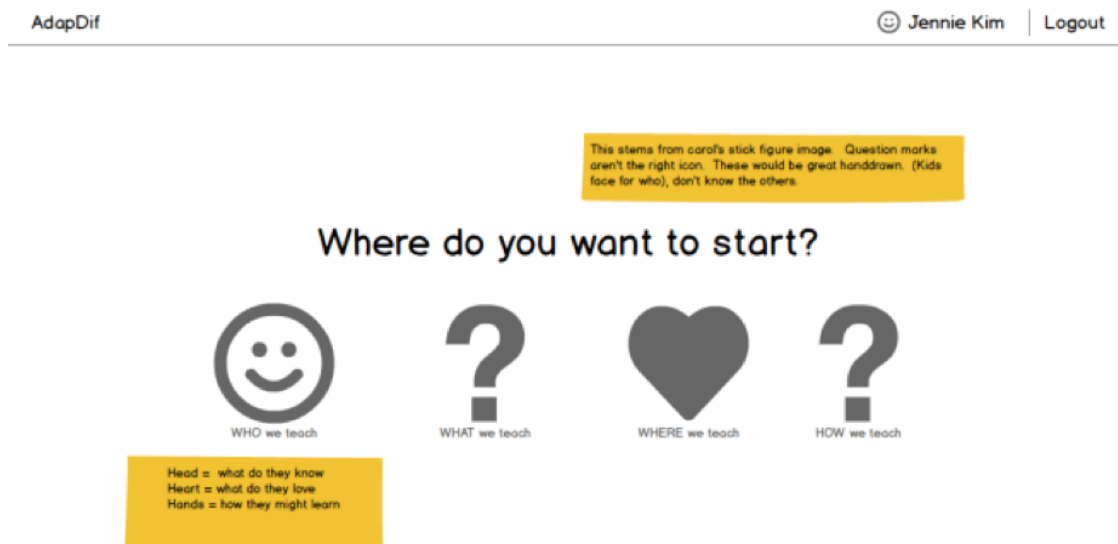
Wireframe. Idea for Models and Strategies page, screenshot (Balsamiq Mock-Ups, date).
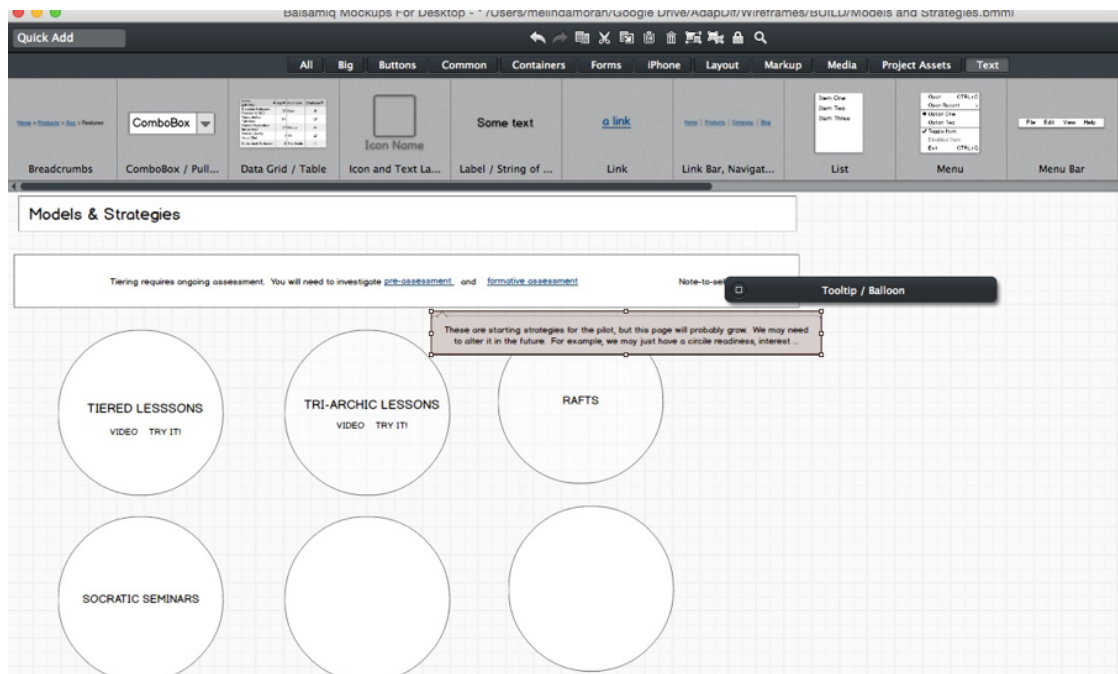
Wireframe. Idea for GroupMat design, screenshot (Balsamiq Mock-Ups).
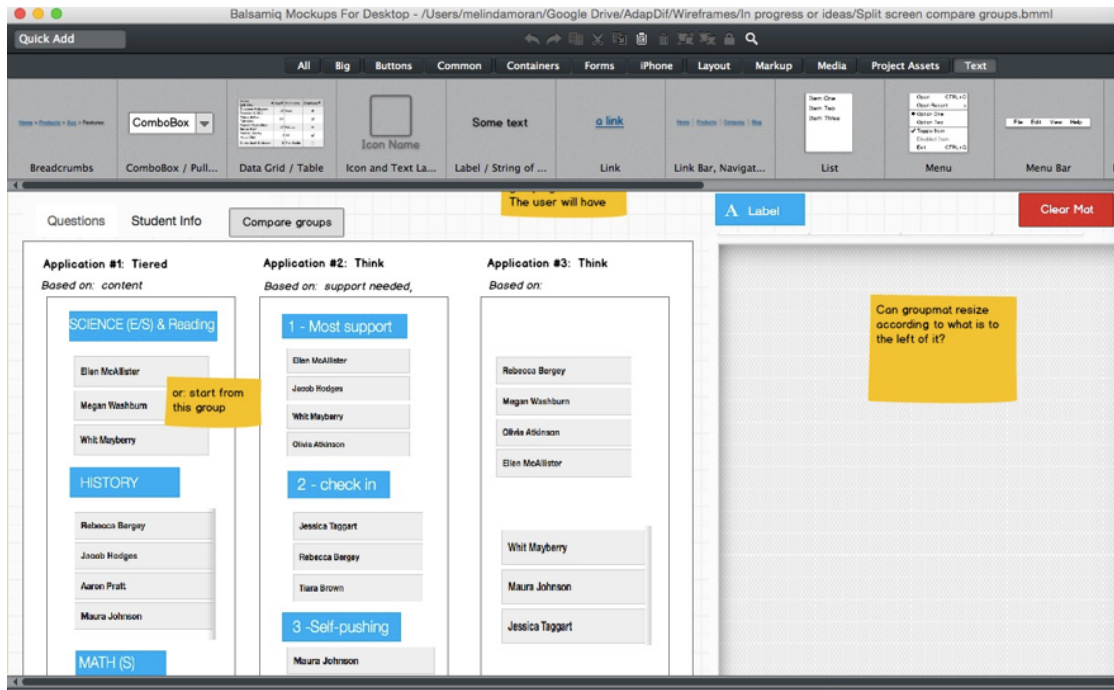
Examples of funding pitches

Keynote slides from Gallant pitch

Examples of grant proposals

2. Priorities

PRIORITY 1: Education Technology Products Used by Students or Teachers (or Other Instructional Personnel) in Authentic Education Settings

3. Abstract

Technical Abstract

Adapting instruction in the classroom based on student needs is the core tenet of differentiation instruction and has been a goal for administrators and educators in the last decades. AdapDif, LLC, is the first initiative that combines high levels domain expertise, supported by Dr. Carol Tomlinson, with state-of-the-art educational technology methodologies into a product that is affordable and practical for teachers to use every day.

Our web-based application provides a host of digital tools that allow teachers to continuously gather both qualitative and quantitative information about students, build a student profiles, use digital tools with this information instructional tasks (e.g. building groups), all overlaid with just-in-time professional development tools. Our one-stop-shop or "connected differentiation" application helps teachers improve their understanding of differentiation best- practices and use time-saving tools to implement its principles in any classroom from kindergarten to higher education.

Commercial Potential of the Product

Our product addresses a proven need as expressed by educators to have a research based digital tool to improve differentiation. The familiarity of the founder with education and support from experts in the field, as well as the technical innovation in the form of online application makes this a low cost attractive offer for schools compared to other PD or technology expenditures towards differentiation. It has the potential to become a vital tool used by millions of teachers in the US and global market with 5% of market penetration bringing in an estimated $20-30 million in annual revenue.

4. Certifications

Small Business Certification

Does the offeror certify that it is a small business concern and meets the definition as stated in the program solicitation or that it will meet that definition at the time of award?

[X] Yes   [ ] No

Socially and Economically Disadvantaged SBC Certification

Does the offeror qualify as a socially and economically disadvantaged SBC and meet the definition as stated in this program solicitation?
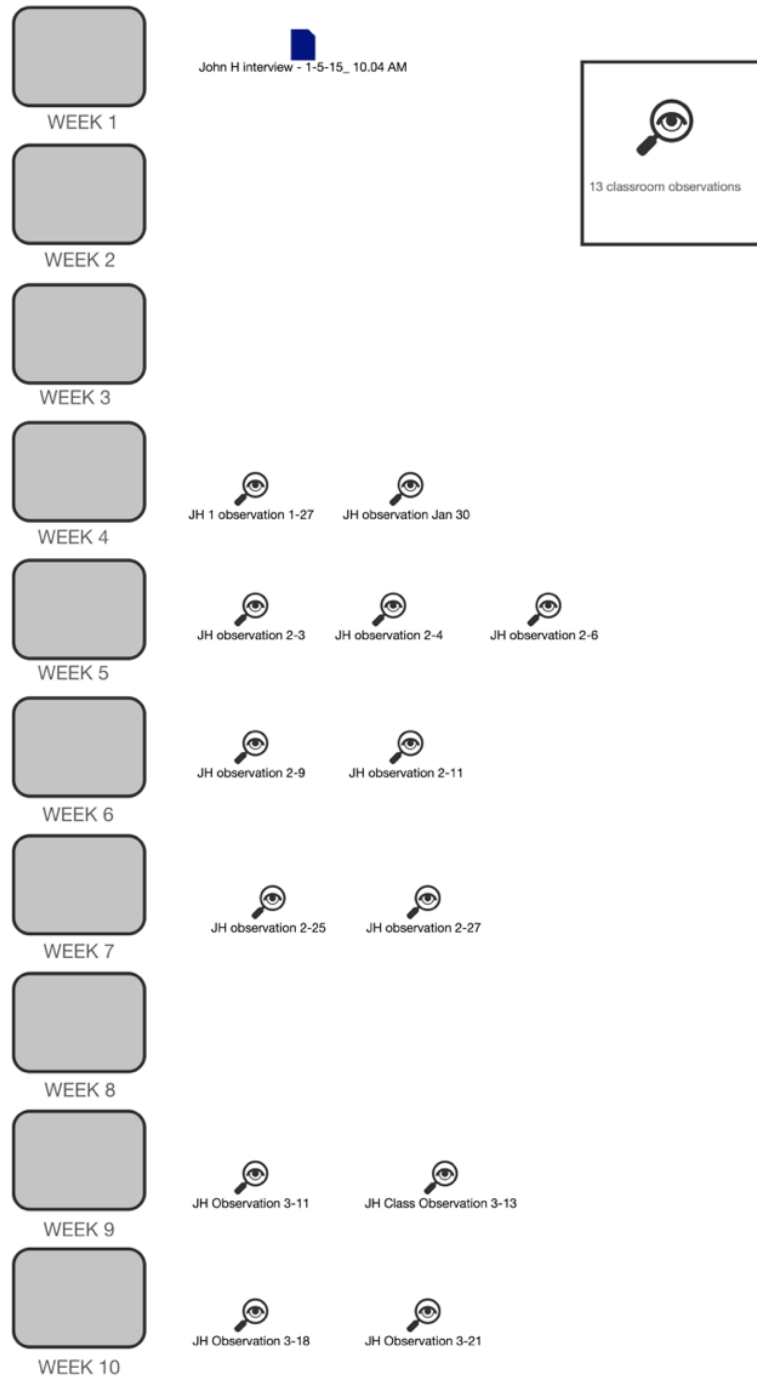
[ ] Yes   **[X] No**

Woman-owned SBC Certification

Does the offeror qualify as a woman-owned SBC and meet the definition as stated in this

Appendix B

Data collection timeline: High School User

WEEK 1

John H interview - 1-5-15_ 10.04 AM

13 classroom observations

WEEK 2

WEEK 3

WEEK 4

JH 1 observation 1-27   JH observation Jan 30

WEEK 5

JH observation 2-3   JH observation 2-4   JH observation 2-6

WEEK 6

JH observation 2-9   JH observation 2-11

WEEK 7

JH observation 2-25   JH observation 2-27

WEEK 8

WEEK 9

JH Observation 3-11   JH Class Observation 3-13

WEEK 10

JH Observation 3-18   JH Observation 3-21

Data Collection Timelines

Appendix C

Data Source Examples from Phase II

Observation protocol

RQ 1: What are the affordances and limitations of an online tool designed to support

teachers attempting to differentiate instruction?

Look/listen for:

- How does the teacher use the tool?

- How does the teacher adhere to principles and practices of differentiation?

- What is the environment like?

- What is the curriculum based on?

- How does she use assessment?

- Design instruction based on assessed student needs?

- To what extent does she lead students and manage classroom routines that

    allow for flexibility?

- What are his/her grouping practices?

RQ 2: To what extent does the tool cause teachers to reflect on their instructional

practice?

Look/listen for:

- Comments about their instruction relative to the tool

RQ 3: How might the tool be adjusted to better support teachers in differentiating

instruction?

Look/listen for:

- Suggestions about the how the tool functions

- Elements of differentiation which the user struggles with or does not adhere

  to

<div align="center">Classroom observation field note excerpt</div>

M observation of Block 2

10:15 (arrive) – 11:55

I arrive early so that I can help with the Homework groups she was making yesterday. I

printed out the groups she was creating yesterday, although they did not look finished.

[Note: She uses the doc camera way more than plugging the computer into the

ActivBoard.] There is a co-teacher in the room for SPED.

It is the tail end of another class. They are silently doing research on their computers.

She is talking quietly with a student at her desk as I walk in. She then records grades

from journal responses onto a clipboard. I apologize for coming in early, but tell her I

brought a printed copy of where she left off if she wants to try to use them. [AN Note: I

am feeling like she may "give up" on the tool and want to facilitate its use since

yesterday we had glitches with the GroupMat items not working. She had been trying to

group based on questions she'd asked in the former survey, but it was not helpful because

she'd asked questions where students could select more than one answer. It doesn't

group smoothly on the mat.)

Classroom artifact
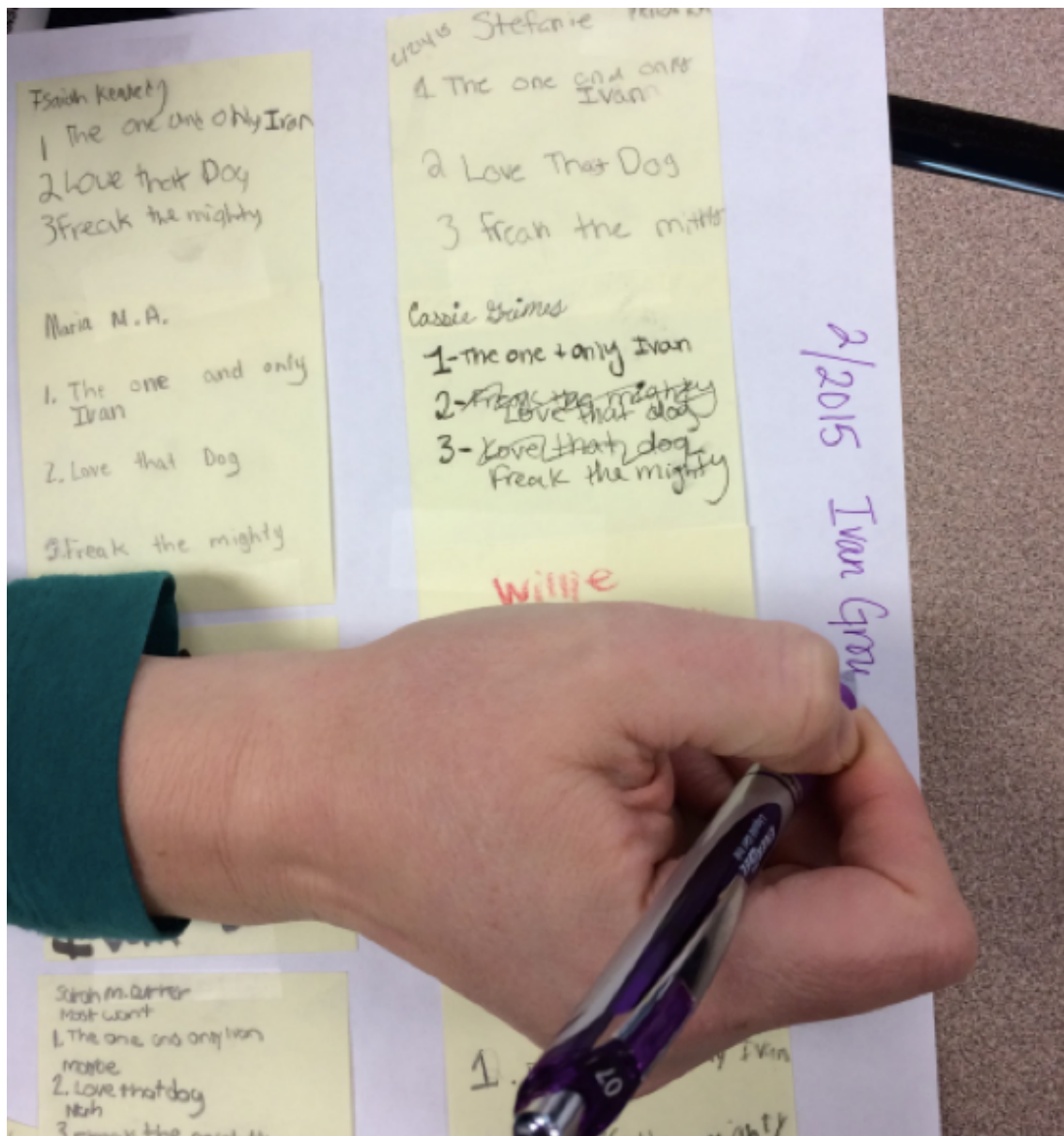
Photograph of teacher's "analog" grouping practice

Email excerpt

Typical exchange with teacher using app

45	**1/29/15**
46	**2:08**
47	From:

48 Yeah- unfortunately I tried to form the groups yesterday without the headings and I couldn't figure out which group was which. Also, the sign in page caused problems even in Chrome so they went through their email which worked fine. Good news— I got every student to complete the survey that was here yesterday.

49

50	**1/29/15**
51	**2:20**
52	From: Mindy

53 Crap. Can I help in some way? Are you still going to try to group with it or needed to abandon?

54 Thanks/sorry!

55	**1/29/15**
56	**2:23**
57	From:

58 We worked it through it yesterday and did group work. I think I might use
59 it tomorrow based on the topic they choose for independent research.
60 Will the categories show up in the Group Mat if we do a similar survey
61 tomorrow?

Interview protocol and transcript excerpt

1) Talk to me about your experience with the app.
      Can you tell me a bit more about …
      Can you illustrate …
2) What inhibited your use of the application?
      What compelled you to use it?
      Of the different tools, which did you use?
      To what degree were they helpful?
3) Brainstorm with me ways that we could change to application. What elements do you wish it had?
4) In what ways was the application useful in understanding or dealing with student differences?
5) Have you found a way for the information you gathered to inform your planning and instruction?

V. Interview 1 audio - 1_5_15_ 10.24 AM

1
2 *Intvr:*   *It's not too many questions. But the bottom-line is we are at the school juncture with the development, where every feedback we get is useful. What was helpful about the application, what hindered you from using it, whatever? So, don't feel the need to be complimentary or worry about my feelings or anything like that. It's just purely all feedback helps.*

3 Resp: Okay.

4 *Intvr:*   *So, I guess if you want to just talk to me about your experience using it or if you want to start there, if you have.*

5 Resp: Do you still have the feedback that I did, when I did it right away? Not that I need to hear it,but did you guys receive that feedback, because I didn't keep track of what I'd?

6 *Intvr:*   *Oh anything you sent in.*

7 Resp: You've got them.

8 *Intvr:*   *The day we sat there, I don't know how much I wrote down in terms of.*

9 Resp: No. I mean when I did the role of notes.

10 *Intvr:*   *Yes.*

11 Resp: Perfect. That's great. So, I really liked using it. I wanted to use it on the iPad, but I found that I was much slower at typing on the iPad. So, I went back to using my laptop. But that did add a degree of difficulty for me. So, I think for me,in order to keep using it and to its fullest, I need to get a keyboard to go with my iPad.

12 *Intvr:*   *So, it wasn't so much the laptop, I mean it was the application itself, it was the function of typing on an iPad.*

13 Resp: It was the function of typing on an iPad.

14 *Intvr:*   *That was by using quick notes like quick notes.*

15 Resp: Yes.

16 *Intvr:*   *Okay.*

interview - 1-5-15_ 10.04 AM

Intvr: *Right here,or whatever is in the back, look at this fancy like?*

Resp: That is really nice.

Intvr: *Okay. I guess the general first question, and I guess I will just say, if you can just talk to me about your experiencewith using the app. I don't know when you bailed on it, because I haven't looked at your usage patterns or anything like that. Because you had the experience of, here take it at the very beginning. So, I don't know when you stopped using it or?*

Resp: So, I used it a lot at the beginning of the year.

Intvr: *Which was literally before school started?*

Resp: Before school started trying to setup and then trying to play with it a little bit.So, working with the kind of notes features.As I found out new things about students as their IPs or whatever coming through, just jotting down little notes about them. Then as students came to school, I did introductory surveys with them kind of getting to know you, kinds of questions. So, for my seniors, a lot of about what I want to know within is like what are their ambitions after next year or this year is over. So, asking those kinds of questions, but also kind of gauging their interest in the material too, because it is a big difference between the students who like to talk about politics at home and those who don't. So, that is always sort of interesting to me. So, anyway I used it for that. I did try to create some surveys and try to do some of the grouping them according to various things, ability or what not, or interest. That became, I felt like it wasn't as easy to use as I think I would have liked to, or I didn't know how to use it as effectively to the.

Intvr: *That's really possible.If you don't have the memoriesdon't worry, just go on.*

Resp: Right.

Intvr: *Which part of it,was it the group map itself or the?*

Resp: The group mat, yeah I think. I think what happens is, one when you're trying to retrieve the question you want to kind of establish the grouping that sometimes you have to dig through a bunch of questions.Or I don't know how to filter the questions effectively and efficiently and I do take the time to do it.

1 This transcript represents a think-aloud of VM planning her book groups which she does by interest. She typically collects students' top two-three choices on a post it note, and spreads them out on a table in her room. (See images and description in other document.) This is an example of differenitating instruction by interest, and more, importantily deliberate **grouping** by the teacher, not random or simply by book.

2 V: I was just going into Illuminate becasue I felt like the thing that might help me as far as ... I dont 'have fluency scores this year, and usually I have a fluency score to go on, and they've changed what they expected of us this year as far as beginning of the year information gathering, so I didn't do a fluency score and I feel like that would help ... in the past it's helped me when I'm setting up book clubs because then if their fluency is very different and with the person with the lower fluency there isn't a real push with the novel to keep going and to keep up with everybody, then you end up with one person with too much extra time and one person who is feeling behind the whole time. So, I'm disappointed I don't have that.

3 M: When you make the groups, it wouldn't just be the choice of books, you're also going to be strategic about reading levels —

4 V: I try to be. I don't promise them their first choice. I say, "I try to get you one of your top 3." If there are 6 choices, and I get you one of your top 3, I'm ok.

5 M: So you would typically do what you are doing right now —

6 V: My second choice was to use their MAP scores, because I felt like the SOL scores weren't going to tell me ... it was just comparing them to a 6th grade level versus comparing them to something that pushes them as far as they can go. So that's why I wanted to use the MAP reading.

7 (Clicking through Illuminate.)

Think Aloud excerpt

AdapDif User-created content

Summary of "grouping events" created by middle school user in AdapDif
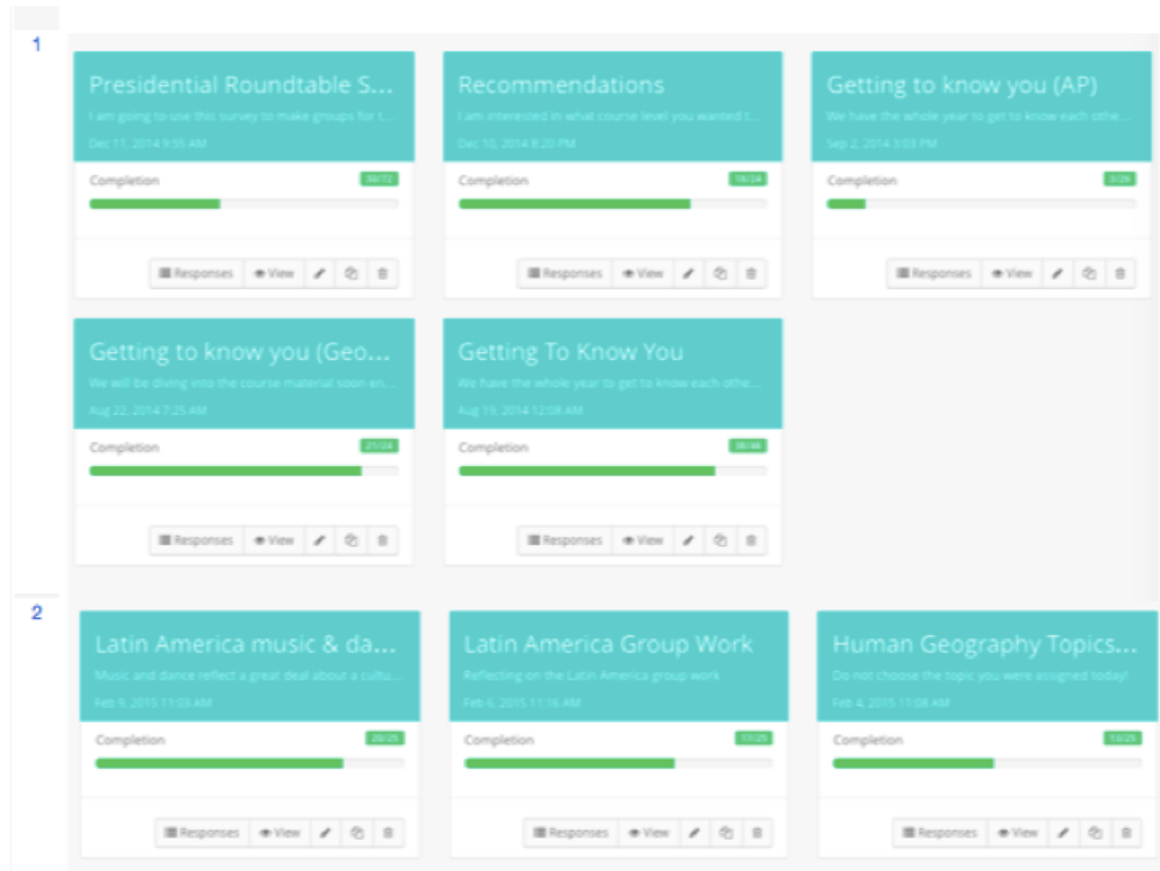
Partial summary of surveys created by high school user in AdapDif.

User issues

Image from screencast video that illustrates an issue with the software for the

programmer to fix.

Appendix D

Coding system, Phase II

Emergent Codes		
Emerging Pattern		Inferences made from data during coding, can be global or specific to pilot user.
	Dancing Around Differentiation	Instances where participant came close to enacting differentiation (or talked about it, but did not fully execute
	Ease of Use	Teacher indicated the importance of technology or differentation needing to be ease to use
	Developer-user as partners	The reoccurance of the reseracher/ developer and teacher acting in concert for the betterment of the product and/or instruction. *This may influence the methods as "Action research."
	Collaborating/Coaching	Teachers working together either with colleague or AdapDif team
	Developer want vs. customer need	Tension between edifying or teaching the user and pandering or "giving them what they want" (i.e., an imperative in a product testing Alex Cowan/lean model_.
	Developer "intrusion"	Moments in the pilot data (e.g., interactions with users) in which my bias as the developer intrudes (i.e., I express an opinion about the app or other technology or instruction OR has to show the teacher how to use it.)
The Teacher		Data that paints a picture of the teacher's style
	Experience	How long teacher has been in the classroom
	Flexibility	Indications that the teacher is not rigid in his/her classroom or thinking
	Problem/need/painpoint	An expression of a classroom problem that might be addressed by an app or training. These are expressed by the teacher or noticed by the researcher.
	Control/Admin	Teachers express disdain for contol of outside forces

		Testing/Test Prep	Mention of standardized testing
		Complexity	Where are they having issues with complexity of differentiaion/instruction/curriciulum
		Time/Work	Relative to teachers ability to plan for and deliver instruction (including assessment.)
		Grading	grading as time prohibitive/lack of time for
	Style		Teacher exhibits his/her unique flair in the classroom
	Teacher Content Knowledge		Expertise in content area
	Teacher Belief		Stated or implied acccpetance that something is true about teaching or education
General practice			Actions by teacher that are indicative of general classroom practice (i.e., not necessarily indicative of differentiation, but with potentially related to.) These codes emerged from the first pass at the data.
	Conferencing		Meeting with students one on one
	Whole Group Instruction		Instruction to all students without modification
		Calling on students	How the teacher recognizes students in discussions or with questions
	Assessment		This includes SOLs, MAP, classroom assessments both formal and informal.
	Classroom mgt		Evidence of general practices related to how the classroom is run, what structures are in place (e.g., routines, procedures).
	External expectations		These state, division, administration pressures such as SOLs felt by teacher.
	Feedback		How the teacher communicates to students on progress or work
	Grading		References to how teachers assess students
	Grouping		Students working in small groups or pairs.
	Homework		Mentions of how students do work at home and how it is handled in the classroom

	Questioning		These are the types of questions the teacher asks whether posted or during instruction.	
	Routines		This indicates a more general routine and not necessarily one that is indicative of "leading students managning routines."	
	Teaching strategies			Teachers' instructional choices
		Lit Circles/Book Groups	Grouping students around a common text they have chosen	
		Workshop	Students working independently on writing or reading with teacher meetings and mini-lessons	
		Independent work	Students working on self-directed task	
		Varied tasks		
		philosphical chairs	Students debating issue with systematic structure	
	tracking		Student placed in separate courses by "ability"	
Differentiation				
	Issues with		Teachers' dissonance with a differentation	
	Practice		These codes are assigned only when this practice is evidenced in the classroom OR when there is a missed opportunity (i.e., the teacher is close to the practice).	
		Respectful tasks	Learning experiences of equal engagement for all learners	
		Teaching Up	Developing tasks that challenge students who are advanced in a topic or content area and scaffold for others	
		Proactive planning	Creating tasks with student differences in mind	
		"Knowing" students	The behavior supports the practice of "being a student of your students." This could include taking notes on them individually, saying something specific to them that indicates specific knowledge about an individual, or other action that suggests the teacher knows the student.	

		Flexible grouping	Evidence that groups are not static, that they have been established for this task or a set of tasks and/or are based on interest, readiness or learning preferences.
	Principle		These codes are assigned only when this principle is evidenced in the classroom OR when there is a missed opportunity (i.e., the teacher is close to the principle).
		High Quality Curriculum	Indicators of high quality curriculum include clear learning goals that articulate essential understandings of a topic/discipne (and can be articualted as essential questions) or learning activites that engage students in those principles/concepts and/or provide oppoturnites for meaninful or authentic transfer
		Ongoing Assessment	Both informal and formal, examples of the teacher trying to understand where students' knowledge, understanding or skills are with the intent of acting on that data.
		Safe & Flexible Learning Environment	Learning Environment includes physical and affective attributes that the tone and generates agency in students; evidence that 1) growth is valued and risk is safe, 2) teachers and students connect, 3) classroom is a community; includes teacher-student connection.
		Modified Instruction	The teacher includes alternate paths/support to learning goals in content (or talks about it) in his/her planning.
		-Readiness (according to)	(according to) readiness
		-Learning profile (according to)	(according to) learning profile
		-Interest (according to)	(according to) interest
		Leading Students & Managing Routines	Indicates that the teacher has set up structures that allow for student autonomy, that he/she leads students and manages routines.
PD/Training/Resources			References to teacher learning, informal and formal, in the interaction. Also as AN where I see an opportunity for PD/training/learning.
	Content		Where teachers are getting their content (e.g., textbooks, online, websites)

Technology			Tools used to support instruction or planning. These could range from digital (such as interactive white board, ipad) to a non-digital tool (such as a worksheet, manilla folder, pen).
	Teacher		Teacher's interaction with technology
		Tcr Analog tool/use	Analog tools used by teachers to assist learning or planning.
		Tcr Digital tool/use	Tools used by teachers to assist student learning or planning (i.e., analog or digital.)
		Facility with	Evidence of how comfortable or proficient the teacher seems to be in using technology in his/her class.
	Student		
		Student tool	Tools used by students to assist learning (i.e., analog or digital.)
		Student use	How students use technology
The App			References to the application built by AdapDif.
	Functionality		How the app could work or worked when teachers used it — problems, issues, ideas/suggestions.
		Functionality: issue	Problem with how the app works (not that something is broken).
		Functionality: BUG/FIX	This references any time a bug was encountered or reported, and/or AdapDif's response to those bugs of bugs
		Functionality: suggestion/use case	These are descriptions of a use case (see Alex Cowan), of a teacher actually trying to use the app a certain way, or making a suggestion about how she'd use it.
		Ideas	These are ideas for development that I think of based on something the teacher/user does or says, and/or the teacher comes up with while using.
	Teacher Use		
		Nudging toward diff	Evidence that the app has, in some way, made them think about differentiation practices
		In class	How teachers use with students

		Planning	How teacher use to plan instruction
		GroupMat	AdapDif tool for grouping
		Student Profile	AdapDif tool that illustrates all data collected about studne in app
		QuickNote	AdapDif tool for taking notes about students
		Survey	AdapDif tool for sending surveys to students
INVIVO			Phases captured in data that may suggest something important.
		random group,	functionality teachers seem to want
		student privacy	concern for student data
		Google	pre-exisiting technology teachers use
		can filter these?	Functionality, possibly important
		spend the time	Time as concern
		academic work time	Phrase VM uses to manage routine
		choice	Teachers want; offer to students
		AVID	ADVANCEMENT VIA INDIVIDUAL DETERMINATION program reference
		homework triads	This is a type of grouping VM uses.

Coding system, Phase I

(citations from Koen, 2014)

New Concept Development			
ENGINE (5 elements)			the inner circle of the NPD model that suggests the ideas flow, circulte and iterate bewteen these 5 elements
	opportunity identification		opportunity identification: the organization identifies opportunities that it might want to pursue, typically driven by business goals
	opportunity analysis		Which opportunities to we analyze?

New Concept Development		
	idea generation and enrichment	idea generation and enrichment: birth, development, and maturation of a concrete idea, going through many iterations and including direct contact with customers
	idea selection	idea selection: selecting which ideas to pursue in order to achieve the most business value
	concept definition	the exit to the NPD stage in which "the innovator must make a compelling case for investment in the business or technology proposition," typically culminating in a business plan or product proposal
Influencing Factors		The FFE exists in an environment of influencing factors. Represents influencing factors which include: • the company's organizational capabilities • customer and competitor influences • the outside world's influences • the depth and strength of enabling sciences and technology
	enabling sciences and technology (depth & strength)	"Since technology typically advances by building upon earlier achievements. Science and technology become enabling when they can be used repeatedly in a product or service. "Enabling" is not the same as "mature," which is defined on a technology trend line or penetration curve. It is the point when the technology is developed enough to build it into a manufactured product or regular service offering. Enabling technologies usually provide some degree of enhanced utility, cost avoidance, value, or quality improvement for the customer. Technologies typically become enabling early in their life cycle." (koen)
	outside world's influences	
	customer and competitor	Complementors are companies that are not direct competitors, that serve to help grow one's industry, and should be considered a sixth force (Grove 1999). For instance, complementors to Microsoft are Intel and Dell. Each of these companies complements the others in building an industry. Government law and policy should be considered a seventh force, because of their impact on the use of and profit from a technology.

New Concept Development		
	company's organizational capabilities	"Organizational capabilities determine whether and how opportunities are identified and analyzed, how ideas are selected and generated, and how concepts and technologies are developed. Organizational capabilities can also include organized or structured efforts in acquiring external technology. Electronics and pharmaceutical companies have a long history of augmenting their product development efforts with external licensing, joint development agree- ments, and the development of testing methodologies and protocols (Slowinski et al. 2000). These capabilities exert influence and give the organization the ability to deal with the influencing factors." (koen)

Appendix E

Summary of user patterns (excerpt)

High School User. JG started the pilot enthusiastically. He emailed AdapDif while still on summer vacation, wanting to get started with the app before his official start date: "You will be able to find me at WAHS from the 14th on. I don't have any indication of how our overlords plan to consumer [sic] our time during pre-service week, but I am guessing that the 14th will pretty much be spoken for." [email, 7/29/14]. The following sequence of emails between JH and AdapDif illustrate his eager initial interactions:

Monday, 8/11/14. Not yet officially back at school, JH wanted to get his students loaded into the system: "I am sending along my class rosters. They are subject to change to some degree but it should not be too drastic. Will the program be ready by next week?" I reported back that our release goal had been the 20th, but I would check on the programmers' progress and, at the very least, we would upload students into the system. I also warned him that I would not have tried out this version yet to find bugs.

In a follow-up email, JH reported shared his enthusiasm with other teachers, "One other question— I am co-teaching one of my classes (MISSION) with two other teachers. Any chance they could have access for that one class?" I replied that we planned to include a sharing function between teachers, but it hadn't been built yet due to unresolved issues with privacy (e.g., teachers can only see certain students according to FERPA), and we hadn't solved it yet, programmatically. I suggested that his co-teachers could have accounts, too, but the profiles just wouldn't sync with his. . He said he would talk to them but thought "having separate accounts that are not in synch might get cumbersome."

Friday, 8/15/14. AdapDif requested a list of his students' emails: "We can set up the classes with dummy addresses for now, but you won't be able to send out any surveys yet. (We don't have a username/login system in place yet — only the push to emails.) We can go back and add the addresses when you have them — whatever is easiest for you. Without the emails, you will be able to use the note-taking & GroupMat. I think you'll want to use surveys, though, too."

JG responded, "Yes, but it is going to take a little time. I cannot create a report with their email addresses, but the database administrator can. She is going to send me a list of all my students with their email addresses. I will have to sort them by class. I am thinking I can get this to you Monday."

Tuesday, 8/19/14, 1:39 p.m. AdapDif reported the application was ready to launch: "Should be good to go w/in the hour. I'll email you as soon as it's a go. Sorry this is right at the wire. I added the students you sent. I combined your excel sheets into one master. Notice we are missing about 4 emails. I gave them 'noemail@email.com' until we get them. This means they won't receive a survey, unless you can find an email. Easy to add." JH guessed these were new students and said he would add them "asap."

By 2:07 p.m. JH emailed that he would start "playing" with the app, and by 3:38 he had created his classes.

Appendix F

Sample from Methodological Journal

3/15
It is admittedly slightly painful to hear (for example in the Think Aloud) when something
doesn't work on the app. The value of an actual recorded interaction is invaluable to
"keep me honest" in scrutinizing the process, and not just remembering the success or
excuses (and, conversely, getting credit for those successes "I like this!" or "oohhh!")

6/30/15
Limitation in data. Because I am concurrently helping with technological glitches and
making the app work, observations are sometimes truncated/interrupted

AN: With VM I should outline her pre-existing practices/routines — like homework
checking, homework triads, maybe how she gives feedback on assessment, writing
workshops — and see where there is a) opporutnity for differetiation (more deliberate
decisions based on data) or b) where her cognitive or workload could be made lighter by
app, and c) aks whether freeing that load would lead to more differnetion.

4/12/17
This fear that teachers will abandon a technology tool if it has bugs or doesn't perform
the way they want is a bias I bring to development and perhaps hindered development. I
don't know if this is real (e.g. supported by this research or any research), but it is an
instinct based on hundreds of trainings in the field where teachers' behaviors were to
dismiss a tool when there was even a hint of undependablitly. This may be looking at the
wrong teachers, though. The persistent ones were perhaps those who 1) wanted to use the
tool/saw that it filled a need or solved a problem 2) were used to troubleshooting. There
was another contingent in training of teachers who simply wanted a username and
password and to explore without interference. I wonder if this could connect to the "early
adopter" types of users in technology — this may show up in development.

2/4/18 3:09 PM melindamoran
As I revisit the first round of codes, my initial thinking starts to shift about the teacher's
willingness to use the app. Without analysis, I would have said VM was less enthusistic,
I think, based on the fact that JH used it in such a intensive flurry. VH was simply more
measured (seemingly) and planned in longer intervals. She, I think, folded it into pre-
existing structures (book groups, homework triads, conferencing). JH, I believe, let it
shape his instruction a bit more. I'll have to see if that bears out. It feels like he used the
surveys often to make decisions. Not sure if his use, and hers, was more structural than
impacting instruction. We shall see.

I am also recognizing the fluidity of both teachers, in terms of how unflustered they are
— VM when making groups (and when emails don't work? don't know?) and JH, I think,
it troubleshooting technology when it didn't work, e.g. the firewall at the school.

Appendix G

Caner's Persona

Jennie has been teaching for about 6 years now and she still likes her job a lot. Things have certainly become a bit easier not that she settled in to her school and knows how things work but her job continues to consume most of her time. Mostly she is trying to get resources for her teaching. She now has lots of content for her classes, especially the difficult one, AP Biology. She has good resources and feels good about her skills as a teacher. Still though every year several students fail her class and Jennie is feeling pressure from parents and the school administration about how to reach out to these kids. She feels like most of her time is spent on these students and many other students aren't getting enough attention.

Preparing for her teaching leaves Jennie exhausted every night, she can hardly make time for her two kids, Alice (2) and Claire (6). Jennie is well organized and her goal every week is to leave the school work behind so she can at least take time off over the weekend and do her favourite things with her kids and husband like going to the Sheldon Park nearby for long walks alongside the creek and shopping at the local market. Often though she needs to sit down to work Sunday evenings after kids go to sleep and she wakes most Monday's with a feeling of being overwhelmed.

In the classroom Jennie is trying to take notes so that she can get to know her students better. She has folders of notes but usually has a hard time finding the right information. Recently her colleague Mary showed her an online system called Evernote which can help her take notes there. Jennie likes the new system but Evernote doesn't seem to solve her problem with notes. She needs to still sit down and try to make sense of the notes and organize them in order to do something useful. She would like to order her information in different ways but the note taking is too rigid to allow anything dynamic. Another colleague James told her to use a database system instead but Jennie doesn't feel like she is up to the task of figuring out a whole new program that is supposed to somehow help her save time.

This would have been much easier if she only had the AP class but with her regular Biology classes she has more than 90 students and sometimes she even blanks out on some of their names. Jennie sometimes wonders if she is a bad teacher, but she goes to all the PD trainings and takes meticulous notes but this doesn't help with the classroom. A few days ago the History teacher in her school, Kelly; wanted talked to her about Juan, who she said was constantly distracted because Juan's sister got really sick a month ago. "Since then," Kelly had said, "he almost never talks in class or group discussions". Jennie was taken aback, not only did she not know about Juan's situation, Jennie couldn't

remember whether he participated discussions in her class. Later on Jennie digged in some notes and saw that she had written it down twice in her book that Juan seemed distracted and did not participate but it got lost among all the other notes she was taking. "So much for my system", she thought; "I wonder what else I'm missing."

Appendix H

Caner's Sprints (9/27/14)

ISSUES that impact usage

☐ make class viewable on "All Surveys" page (e.g. show "EDLF 7390" — right now I can only filter for it if I've tagged the survey with the class name) [this is conceptually complicated]

☐ text is too light in grouping side bar student responses. It is grey and very hard to read for (old) teachers. :)

☑ activate Student Notes section to work in the class view (i.e. can filter for class patterns)

☐ make student's class visible in "All Notes" at the bottom of quick note page (i.e., so system can filter for it)

☐ **preview mode of survey** allows you to click on bubbles, and more than one, which suggests that that's how it will work when sent to students. It is not how it will work, though, since they are multiple choice. Probably best if the preview mode isn't interactive or reflects how the items really work:

☐ Now that I've filtered, **I need to be able to resend email reminder** with the link included. We could do it from the survey view below, if that's an easy fix. Right now I have to toggle back to the survey and resend it to each individual student. I also have no way of knowing who those students are unless I write it down from this page, which is clearly arduous. [This scenario occurs with every survey, I am finding.]

☐ When the user clears the canvas (in the scenario below), **we need the system to know that a NEW grouping is being made**, hence erasing the Title and Tags boxes and logging it as a new grouping, not simply saving over the last grouping.

☐ Students should be able to pause and save their surveys OR if they leave the data is deleted and they have to start again. They should not be able to sent twice.

☐ Responses should show empty as "skipped".

☐ Double password, check for matching

☐ *Emails are not sending to entire class at any time. Start a ticket with MediaTemple.*

☐ Duplicating a question moves some questions and changes the type of question and details of random questions. (Maybe allow multiple field is not copying). Group -> questions are loading multiple times based on sending instances. //

☐ Groupnet boxes a little too big

FEATURES/Enhancements

☐ need a "random" on grouping page

☐ need a jigsaw function in grouping which we need to sketch out (i.e. from a grouping, hit "jigsaw" which puts a representative member of each group into new groups, need your logic on this)

☐ add "growth" as a tag option on quickness

☑ *quick note* needing to be accessible without leaving a page (e.g., in groups … pretty much anywhere you get an "aha" and you don't want to leave your environment)

☐ **Need to be able to copy/duplicate a grouping** (so that grouping can be reused with different directions) Add duplicate button to the group events which creates a new group

☐ Need to be able to *quickly* **associate quick note with a grouping** (e.g. talking notes during small group work; reviewing a group project)

☐ **Make templates usable so Mindy can start getting them in there for users** (1) adding questions, (2) how will we indicate visually that these are "template" questions?

☐ **Check group mat student information (it comes up when the name is on the mat but not from list of students not on the mat)**

☐ Word cloud *from all the survey responses* that can be full screened.

☐ **Can we "group" straight from the responses (for multiple choice, obvs.) - Priority (but where does it go? a blank mat? — open the group mat with THIS question)**

☐ Banner across the top that we can feed with rotating quotes (mindset/Carol) or questions that trigger differentiation thinking. (feature idea)

☐ Wizard or help layer [before March 28]

Appendix I

Persona examples created by Mindy

PERSONAS: teachers

ASHLEY is a 20+ year veteran, K-5 teacher who is a "departmentalized" math teacher, meaning that she teaches math for her grade level (80+ students.) She "really needs a streamlined way to meet student needs." She expects to be treated as a professional and "feels it is important for me to learn from a professional." She is skeptical of "fluff" such as some of the learning styles workshops she's been forced to attend and is interested in "tested and practical strategies, and ways to manage a diverse classroom in an efficient and effective manner, and be able to track the results of my teaching."

BILL is a middle school teacher who is "interested in learning how to better differentiate my middle school math classroom." The examples of differentiation he has seen and read about are most often in an elementary classroom or in a reading/writing classroom, and these have been helpful, but he is "not sure how to effectively implement this into Math." His school has an accelerated pre-algebra class and even within that group there are many different levels of knowledge, etc. He would like "to learn how to best differentiate for this variety of levels."

CLARE is fresh out of a teacher-training program in Virginia (and close the to differentiation "flame" of Carol Tomlinson) and about to take on her first year of teaching at a small, private school serving an affluent K-8 population. She has a part-time contract as the Humanities teacher for 5th through 8th grade. (This means the school can only afford a half-time position). She has had extensive training in differentiation and is ready to incorporate all of its principles into her own classroom. She is a bit intimidated because she understands the amount of time and investment that will go into creating a successful differentiated classroom and wants to do a good job of it—as a first year teacher, she worries that it might be near impossible to achieve all she wants to. She wishes there was a way to make Differentiation a little bit easier, or at least more time effective, to implement. The one area in which she feels underprepared is in incorporating technology into her classroom practices—she is reluctant to take risks with new technology and has only been trained in the essentials (Microsoft Word & PowerPoint). She rationalizes this by saying that technology is always changing so rapidly, so what's the point of investing in learning about something like a SmartBoard when it will be outdated in a year? There weren't any professors at the University level that made technology user-friendly and accessible to her, so she avoided it all together, hoping she could get by without it.

KRISTY is an overworked but caring teacher in a Title I urban charter school in Sacramento, CA. She has been teaching for three years and is a single 20-something for whom teaching takes up hours far beyond school day (7:30-5:30) after which she goes home to grade—there is little time in her schedule to enjoy her personal hobbies like line

dancing and training for marathons, a hobby she used to love in college. As an undergraduate and master's student in a teacher-training program at UCLA, she read Tomlinson's books and learned about differentiation. She thought the concept of differentiation was meaningful, and she was more curious about it but found that there was no one to answer her questions. She'd ask professors what Differentiation was, but their questions didn't always align with what she'd read in the books, so she wasn't sure if it was correct or not. She now has Tomlinson's books sitting on her bookshelf in her one bedroom apartment and hasn't opened them since she graduated. She found out about Carol's Summer Institutes conference at UVa that would cost $800 for the week plus airfare and lodging, and requested financial support from the district. Despite her eagerness and persistence, the district couldn't give her the money she would need to make it. She has the passion and readiness to differentiate effectively, but not the financial resources to get access to the training she needs in order to incorporate it into her classroom practices to reach her students where they are.

ERIC is a matter-of-fact, rules-oriented kind of guy. He teaches middle school science and is notorious for asking visiting trainers how whatever they are suggesting aligns with Virginia's state standards (SOL's). He doesn't like getting too theoretical or philosophical about teaching – he uses a lot of hands-on activities in class and he "wants more activities added in my toolbox of teaching strategies." He wants to see concrete "examples of differentiated instructions or teaching techniques." He stays out of the teacher's lounge, eats lunch in his room, and does not engage in school politics. His motto is, if it works, I'll do it.

LINDA is a high school teacher who is "highly motivated to 'think outside the box' in order to improve the quality of instruction in my classroom." She has had extensive training from one of Tomlinson's protégés and, as a result of this training, "has given professional development presentations on the topic to my colleagues during our district institute days and planning periods." She wants "to continue to improve my ability to differentiate my lessons."   Her principal views her as a leader on campus, while some of the more jaded staff believe the only reason differentiation works for her is that she has no life, and whereas they do. She has aspirations to move into consulting one day and is interested in networking with experts in the field.

CHAD has been teaching History for nine years now, and just moved to Belmont, MA, with his wife and newborn daughter. He teaches AP US History to a group of very intelligent 12th graders at an affluent public high school. These students are all at the top of their class, and most are applying to Ivy League universities. While all of the kids in his class are high achieving, he has discovered that not all of them are passionate about History—they are simply taking it for the AP credit to boost their GPA. He wants to figure out a way how to incorporate their different outside interests into his curriculum to make it more meaningful and personal for them, in order to help them retain it and find a deeper, vested interest in the subject he cares about so much. He hasn't yet heard of Differentiation as a mode for reaching a wide variety of students, but if he had heard of it,

he would certainly give it a try. The district is pushing for professional development in incorporating technology into the classroom, and he is looking for something that will support him in his quest to reach all of his students.

BETH has just joined Peace Corps and moved to Rwanda to teach 9th grade English to students who range from age 10 to age 60. She grew up on Long Island and went to a Waldorf School for K-12, then went to Middlebury College to earn a degree in International Relations. She has no teaching experience, and has no idea where to begin with her African students who are depending on her to learn English. She wakes up every morning and walks through the small, impoverished village on her way to school, wondering why these students care so much about education when people at home in the U.S. seem to disregard it. When she arrives at her classroom and looks at the 60 students sitting on the dirt floor eagerly awaiting her instruction, she wishes there was a way to reach them all.

 PERSONAS: leadership

JOHN is the assistant superintendent of a medium-sized school district. He worked his way up the system from being a coach to a principal and up into the head office. He doesn't know a great deal about curriculum and instruction, but he does know that his district's population has shifted over the years: more students are being identified for special ed or with conditions like ADD, more English Language Learners are showing up everyday with parent who speak no English, and the economic downturn has put stressors on the homelives of many children.   He hears his teachers are struggling and over-burdened, and he has a superficial understanding that "differentiation" will cure many of his ills. He is also extrememly concerned about plummeting test scores and a tightened budget.

PAIGE is "the administrator of a K-8 building for gifted learners. I have young and inexperienced staff and want them to gain a sense of confidence with differentiation."
  She has to contend with an over-educated and demanding group of parents who are constantly concerned that their "special" childrens' voices aren't being heard or they aren't being challenged or they have a different way of learning that the teachers aren't recognizing. This parent group gets newsletters from gifted associations and some have abandoned public and even this private school to homeschool. Some are putting their kids in school for the first time after homeschooling. Some view differentiation favorably as it has its roots in gifted ed, but others are skeptical because they have the misconception that it will mean their kids are in classes with students of lesser ability who will slow them down. Paige is concerned for these students who she sees developing fixed mindsets that will hinder their learning and growth.

CYNTHIA has just transitioned from a classroom teacher to an instructional coach. She got her "masters degree years ago in Special Education, which at the time, was the only way to learn how students learn differently. My goal was and is to learn how to work

with students using their talents and learning styles and helping them to build those as well as add to their skills. Her school has "highly intelligent, capable teachers with strong, motivated students."   She "would like to learn more ways/strategies to help students learn, that I can then share with my teachers. I am particularly interested in how to teach children not only at different levels in the classroom, but also to their different strengths simultaneously. I would like to learn how to help teachers be able to do this and learn to better manage the students and groups in the classroom at the same time. I would like to add varying and different classroom management and transition time strategies to my toolbox to share with my teachers. Finally, I hope to learn about a number of NEW and different instructional strategies like, RAFT.

MARCUS is beginning his 4th year as Principal at an elementary school that has not met state AYP for three year in a row. He has a great group of teachers that have complete buy-in to his education philosophy, strategies for school improvement, and students-first attitude. He is facing extreme pressure from the district to get his test results up to proficient or advanced, and is at the point where the state will soon be imposing sanctions if performance does not go up in the next year. Simultaneously, his school is in an area where there are high immigrant populations with families from around the world with little or no English fluency. All teachers and administrators work day in and day out to support these kids and bring them to where they need to be, but it is next to impossible to serve classes of 30 kids from such diverse and troubled backgrounds when they don't even have English literacy in common. He has begun to scan the most recent research on how to address all the needs of a diverse set of learners, and stumbled across Carol's work on Differentiation. He is curious about it and thinks it sounds great, but wonders if it's really effective in a school like his.

GREG is the Professional Development chair at a large district in Seattle, WA. Each year, he is given a certain amount of money from the state to provide professional development for teachers in his district, but this year, the fund has been cut drastically. There is very little money to work with, so he is trying to figure out the most efficient way to spend it. Does he send a few teachers or administrators to a well-known conference in hopes that they can come home and train the others in their school? He worries that important information could get lost in translation as it gets passed down from one person to the next, and wishes there was a cost-effective way for that expert knowledge to be passed down to everyone so that all his teachers could get the same information and training.

Appendix J

Plans for collaborative function in app

Screenshot of Wireframe. This is a blueprint for adding an educational stakeholder, designed after Mr. Grayson and Mrs. Allen both expressed a need to collaborate. (Balsamiq Wireframes, 12/4/14)

SHARE function

If we set-up a way for teacher to share reflective notes, student notes — whatever — could you build in a mechanism that "blocked" the sharing if a student is in the note and the teacher who is receiving the shared note is not an educational stakeholder (in other words, in their roster settings, they have not been given permission to see the kids' notes?

e.g.

teacher hits SHARE and selects people to share with
hits SEND
AdapDif: "You mention JOHN P in this note. Ms. Moran is not recognized as an educational shareholder. Do you want to change her status?

"SHARE function." Functionality and privacy concerns for Caner about collaboration

Collaborate

- Profile page.
- Collaborative element to the profile pages.
- Sort out permissions and privacy issues for building a school network

Collaborative

Export info:
- *General info* about what's happening **to all class specialists** [BUTTON: send to specialists] *in network* (e.g. ESL, interventionist, tutor, gifted pull-out, SPED, reading specialist)
    - Topics from class (e.g. informs content of books to pull)
    - Learning goals (e.g. skills, vocabulary words
- *Specific info* about a student
    - Shows up in their profile

"Collaborate." Ideas about how the app should allow collaboration about students between

Appendix K

LENS project planning Google Doc

Geography Project (World History Artifact Tour)
1.   Nail down regions and anchor them in course of the year.
1.   North America
2.   Latin America and the Caribbean
3.   Europe
4.   North Africa and Middle East
5.   Sub-saharan Africa
6.   The Far East
7.   Australia, Pacific Islands, and Antarctica
8.   Russia/C. Asia

Know: Human endeavor, over time, may be organised into 'families:' engineering, politics, literature, art, politics, religion, science, agriculture.
Significant human and physical characteristics of our earth.
The world may be divided into regions that have distinct demographic and physical characteristics.

Understand: Humans have varied relationships to the world around them, to one another, and to history. Human influence can be constructive as well as destructive.

Do: Independently conduct research and produce high, quality comprehensive projects (traditional and digital) to communicate expertise in the artifacts chosen. Utilise appropriate software (ArcGIS/Google Earth) to create a portfolio of product.

Task: Students are to produce a portfolio of artifacts that communicate a comprehensive knowledge of various human endeavors. As we move through our course of study from region to region, one artifact must be chosen from the 'family' list e.g. engineering. Once that family is chosen, the student may not select it again. By the end of the year, students will have collected all the families.   The artifact will be researched and presented. The final product may be a traditional one page research paper or some sort of digital product; regardless of medium, depth and expertise are the expectation.

Appendix L

Examples of Mrs. Morrison's Quick Notes

conferenced about M/D book club book - strong understanding	
genius hour conference - diagram of how a bowling ball is returned	genius
9/19 - said she had read a book and tried to conference about it for Bingo board, but had not actually read it	reading
9/23 - Can\'t Look Away, fluent reader, rereads to clarify	reading
M was unable to identify the basic components of setting or explain how a reader finds out about a character on today\'s formative. She was able to make an inference about a character trait and provide evidence from a passage of	reading
Emily shared her piece for the Writer\'s Eye application. Strong voice as \"the eye\". Suggested revising some sentences which changed the tone as well as connecting the concluding sentence back to being Melissa\'s eye.	writing
In conferring with J about his personal narrative, I suggested some revisions based on changes in verb tense. He is aware of this being a problem in his writing. Possible Mini Lesson - ways to check your own writing for verb tense	writing
Enrique - found a book he loves - Passport on a Plate. Made his own sticky note code of a chef\'s hat for recipes that he wants to try.	reading
out sick for a week, a little overwhelmed when S worked with him on character traits, keep an eye on this	reading
out sick for a week - worked to catch him up on personal narrative choices and brainstorming - feels confident in this area - using Gantos map idea to brainstorm today	
struggled to get started with personal narrative today - had ideas but wasn\'t ready to write - coached re: choices - was then able to get started	writing
conferenced about finished books for bingo board - enjoyed reading technical article re: development of Apple products and science article re: scat/owl pellets as source of information	reading
Has begun writing three different drafts of her personal narratives. One about chicks, one about finding her favorite book series, and one about going to Florida. She has finished working on two of the pieces and is beginning the	writing
When we handed back the Character and Setting quiz, she changed two answers and then asked why she got them wrong.	test taking
First UVA game	writing
Baking a cake	writing
Disney world	writing
Inspiration for Legos	writing
First time on the Griffin; great focus and concentration; working hard and asking good questions	writing
Sleepover	
Typed drafts in word on laptop, but now has loaner. Will focus on lead today in google drive and then put together tomorrow.	writing
Woodpecker	
Baby chicks	writing
Hide-n-seek	writing
Ice skating for the first time	writ

Appendix M

Mr. Grayson's app use across courses

Class	Survey & Purpose	Questions	Grouping
World Geography	(1/27) **WHAT Part II** *This is help determine groups for brainstorming topics for the next WHAT project*	Which topic interests you the most with regard to human geography of Latin America? 2nd choice?	
	(1/30) **Lens for the WHAT II** *The purpose of this survey is to group you for genius hour activities today based on what lens you might use to research your topic.*	What lens did you choose to research your project?	(1/30) "Lens for WHAT"
	(2/2) **Human Geography Topics: Central America** *Survey for group research*	Which topic interests you the most with regard to human geography of Latin America? 2nd choice?	
	(2/4) **Human Geography Topics: Central America** *Do not choose the topic you were assigned today!*	Which topic interests you the most with regard to human geography of Latin America?	
	(2/6) **Latin America Group Work** *Reflecting on the Latin America group work*	What was something you believed about Latin American before this activity? How has that changed or been reinforced? Think about your role in your group work for Latin America. What was your greatest strength as a group member? What could you have done to make the task or group more successful? What would you change (or keep the same) to make this activity more meaningful to you?	(2/6) "Human Geography Work Groups"

(2/9) **Latin America music & dance** *Music and dance reflect a great deal about a culture. I want to know which area you might want to explore more deeply. Challenge yourself to learn about something unfamiliar!*	Which area would you most like to investigate? [1st choice] Which type of music/dance would you most like to investigate? [1st choice]	(2/10) "Music, Dance, and Food (Latin America)?
2/11 *observation*		
(2/25) **Next Stop** *Do this*	Where do you want to go next?	
(2/27) **Exit ticket** *This will "assess" some of your big picture understanding as we leave South America and pre-assess what you know about Sub-Saharan Africa.*	Why is it important to use a lens when you are researching or presenting a topic? We will be using "movement" as a theme in exploring Sub-Saharan Africa. Movement can allude to people, ideas, products and physical systems. List as many specific examples of "movement" in Africa as you can think of.	
(3/4) **Sub-Saharan Unit Entrance Ticket** *Intended for you to reflect on the enduring understanding of this unit and to express interest in a topic for which you will make a concept map.*	Give an example of how movement (people, ideas, physical systems, materials and etc.) brings "life" to a place. Today, we are going to make a concept map about movement. Which topic interests you the most?	(3/4) "Movement Groups"
(3/4) **Exit Ticket** *Evaluating your understanding of the enduring understanding.*	Give a specific example of how movement (people, ideas, physical systems, materials, etc) brings "life" to a places in Africa	
(3/11) **Human Migration** *We are gauging what human migration you'd be interest in, connecting African physical geography to migration*	Which human migration are you most interested in?	(3/11) "Migration Groups"

(3/13) **Post weekend check-in** *Just checking in ...*	So, describe something awesome you did this weekend. I would rate my weekend a ... Reflect on the political boundaries activities we did-- what were the major factors that influenced how you drew the lines?	
(3/18) **Entrance ticket** *Wrapping up product movement and onto disease movement*	How has diamond mining and the diamond trade changed the cultural landscape of sub-Saharan Africa? Which topic interests you the most?	(3/18) "ideas"?
(4/3) **Topic** *WHAT Topics*	What are some of your topic ideas and how are you planning to present your topic? What are you doing for Spring Break?	
(4/17) WG- Entrance Ticket 4/17 *assess knowledge of subregions of Oceania*	What are the major sub-regions of Oceania? What makes these sub-regions different from each other? (In other words, how is Micronesia different from Melanesia, Australia, Polynesia, and New Zealand?) What is your topic for WHAT project 3? What is the lens? What is the format that you are planning to present?	(4/15) "Subregions of Oceania"
(4/22) **WHAT project 2** *For groups today*	How would you best describe how you are presenting your WHAT topic?	
(4/24) **WHAT Entrance Ticket** *Reflection on WHAT project*	Tell me in 3-4 sentences what you learned doing your WHAT project	
(4/24) **Exit Slip** *On today*	What was the coolest thing you saw today and why? What was one thing you learned today?	

	(4/27) **Interest Survey for Middle East and North African Countries** *Choose which country you would like to research and present for Friday's class.*	Which country would you like to research and present? 2nd choice? How would you prefer to work?	
	(5/20) **What IV** *Exit slip for topics and lenses*	What is your proposed topic? Which lens? What do you know about your topic already?	(5/22) WHAT IV Lens Groups
	(5/27) WHAT Part IV- Status update *I want to get an update with where you are on your final WHAT project.*	Describe your topic-- who, what, when, where, why, and how Which region? What is your lens? Use your lens to construct a thesis statement for your topic.	(5/29) "Feedback WHAT IV groups"
	(6/3) Settlers of Catan Prep	What is your level of experience with Settlers of Catan? Describe your best experience freshman year. What do you look forward to the most this next school year?	(3/3) "Test"
AP Government (7th pd)	n/a	n/a	(3/10) "MC Committees"
	(3/9) **Article on Congres [sic]** *Interest survey for articles that students will read*	What topic about Congress most interests you?	(3/10) "Congress Reading Groups"
	(4/14) **Mock Supreme Court Groups** *Used to determine Mock Supreme Court groups*	What would best describe your judicial philosophy? What was the best thing that happened over Spring Break?	(4/14) "Mock Supreme Court Groups"
	(4/23) **Civil Liberties Interest Survey** *This survey will be used to determine research and presentation groups for next week.*	Which topic most interests you for Civil Liberties or Civil Rights? 2nd choice?	

Advanced Government (3rd pd)	(4/16) **Entrance ticket** *In preparation for SAC on DLK* *(Built and sent, but no student responses)*	Did the government violate DLK's 4th Amendment rights by using a thermal imager prior to obtaining a warrant? State one argument and one piece of evidence that supports your argument. (Evidence can include a quotation, fact, statistic, appeal to common sense, an analogy, etc.) What is your plan for next year?	
	(4/23) **Civil Liberties Interest Survey** *This survey will be used to determine research and presentation groups for next week.*	Which topic most interests you for Civil Liberties or Civil Rights? 2nd choice?	(4/27) "Supreme Court Landmark Cases group"
Advanced Government (8th pd)	*No survey correlated*		(4/11) MC Committees
	(4/17) **Entrance ticket** *In preparation for SAC on DLK* *(Built and sent, but no student responses)*	Did the government violate DLK's 4th Amendment rights by using a thermal imager prior to obtaining a warrant? State one argument and one piece of evidence that supports your argument. (Evidence can include a quotation, fact, statistic, appeal to common sense, an analogy, etc.) What is your plan for next year?	
	(4/23) **Civil Liberties Interest Survey** *This survey will be used to determine research and presentation groups for next week.*	Which topic most interests you for Civil Liberties or Civil Rights? 2nd choice?	
World History to 1500 *Standard*	*Did not use*	*Did not use*	*Did not use*

Appendix N

Table with Mrs. Morrison's Writing Survey items

Table Writing Interest Survey items

(This will help Mrs. Morrison plan our writing work for the second semester.)
 	
What does someone have to do or know in order to write well?
What kinds of writing do you like to write?
   • poetry
   • letters
   • fictional short story
   • persuasive piece
   • book reviews
   • research essay
   • memoir (a type of personal narrative)
   • speech
   • informational article
   • Other :
How do you decide what you'll write about? Where do your ideas come from?
What kinds of responses help you most as a writer?
In general, how do you feel about what you write?
Which should you enjoy first?
   • Book first
   • Movie first
Look at your Writing Goals that you set for yourself earlier this year. Which domain did you choose to focus on? (Hint: look in your journal)
If you chose Organizing and Elaborating, what steps did you select to reach your goal?
If you chose Capitalization/Spelling/Punctuation, what steps did you select to reach your goal?
If you chose Communicating Ideas, what steps did you select to reach your goal?
If you chose Grammar/Structure/Paragraphs, what steps did you select to reach your goal?

Appendix O

Function/feature list 7/4/15

Mr. Grayson observation data
FEATURE:
Content (MM) (JH 1-27)
Poll (MM) (JH 1-27)
Exit slips (JH 2-4)
Prompts to check in with "low-flyers" (JH 2-9)
Dictate quicknote (JH 2-27)
Grouping frequency alert (MM) (JH 3-4)
Ability to submit group assignments to associated gradebook (JH 3-11)
Color coding for group roles (JH 3-11)
Group role assigner (JH 3-11)
Templates (JH Feedback)
Graphic organizer (JH Feedback)
Link for enrollment (JH Feedback)

FUNCTION:
Student evaluation of group experience (JH 2-6)
Copy groups and change instructions (JH 2-6)
Group them based on interest (JH 3-11)
Different instructions already attached to different groups (JH 3-11)
Retrieve questions (JH Feedback)
Recommended time frame for activities (JH Feedback)
Embedding through Blackboard (JH Feedback)
Survey as self-evaluation tool (JH Feedback)

Mrs. Morrison observation data
FEATURE:
Hovering help item (VM 1-11)
Exemplar questions (VM 1-11)
Question suggestions (VM 2-12)
"Groupnote" where several notes open at once or ability to store one note under several
student files (VM 2-27)
Prompt/help guide to new features (VM 3-3) (VM Feedback)
Random group generator for optimal interactions based on previous group data (VM 3-3)
Ability to share notes with students or email (VM 3-3)
Student voice frequency counter (VM 3-12)
"Teachmat" (VM 3-12)
Be able to add note when you click from the (? Sentence ends) (VM Feedback)

Appendix P

Bugs reported by users

User	Date	Issue
Mr. Grayson	August 21, 2014 1:46 PM	So once, I have my survey results and I want to group based on a question----how do I do that. It is not clear to me.
	September 9, 2014 7:46 AM	I made a survey in the beta version for my AP Government students. Only 3 kids have taken the survey. Can I get the survey moved over?
Mrs. Morrison	September 23, 2014 12:29 PM (Tuesday)	Just added some students. Left side of screen at bottom looks like the request didn't process properly or screen is frozen.
	September 23, 2014 3:55 PM	Sorry for all the messages today. This is what happened when I clicked on "edit my profile". Note the frozen screen to the right.
	September 23, 2014 12:30 PM	Re: my prior comment about frozen screen - I had to leave Classes screen and come back to it in order to add more students.
	September 25, 2014 12:41 PM	It seems to be trying to identify every word in my note as a name. Is it possible for it to have more letters match within a word before identifying it as a name?
	October 16, 2014 5:41 AM	Grrrr! I'm trying to write notes based on looking at a student's rough draft. Every time I switch to the tab with their draft, I get locked out of AdapDif and lose what I've written. Now it's also locked me out as I'm typing this. Is there a setting where I can increase the time before it locks? (Sorry for the grumpiness.)

| | October 22, 2014 1:27 PM | Working well so far :) |