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Abstract

This paper describes an effort to develop a survey instrument capable of measuring adolescents' experiences of interest-related pursuits that are supported by technology. The measure focuses on youths' experiences of *connected learning* (Ito et al., 2013), an emerging model of learning across settings supported by digital media. Specifically, the instrument aims to measure the depth with which youth are able to engage in an interest-related pursuit, the level of support and encouragement they receive from peers, and the degree to which their pursuit involves performance or media production as an essential feature. The survey also elicits information regarding the connections between youths' interest-related pursuits and academic goals, the involvement of adults as co-participants in pursuits, and youths' access to technology tools they deem necessary for their pursuits. The paper reports on results from a pilot study and two field tests of these items, in which we evaluated the validity and reliability of the instrument and compared results with evidence from interviews with youth. Our aim was to investigate the feasibility of an approach to measuring youths' interest-related pursuits to inform future research and evaluation of initiatives focused on digital media and learning.

Today, young people with an interest in nearly any topic can use technology to connect with others who share their interests, to make or produce things, and to share their productions with others (Ito et al., 2013; Ito et al., 2009; Jenkins, 2009). These new capabilities are consequential for both learning and educational systems. The fact that young people can pursue interests and learn across a variety of settings indicates there is a need to consider how educational opportunities across different settings might be linked to one another in order to promote better connected learning ecologies (National Research Council, 2015; Traphagen & Traill, 2014). It draws attention to new dimensions of equity as well, particularly to the resilience of the ecosystem manifest in the diversity of pathways through which all youth might follow interest-related pursuits (Ito et al., 2013; Penuel, Lee, & Bevan, 2014).

To date, there have been few attempts to develop and evaluate measures of youths' experiences in technology-supported interest-related pursuits across multiple settings. This kind of work could advance our understanding of interest-related pursuits, both because attempts to develop measures can themselves yield valuable insights into the ways in which interest and engagement are felt and expressed by youths, and because the availability of valid measures can permit the testing of specific claims developed from theories of how interest and learning develop across settings. Such measures can also support investigations into the kinds of supports and resources needed to promote equity of opportunity to engage in interest-related pursuits.

In this paper, we present results from a study in which we developed and evaluated a survey instrument related to youths' experiences of interest-related pursuits across settings and time. More specifically, the survey, which targets youth 13 to 16 years old,

aims to measure multiple dimensions of youths' experiences of *connected learning* within their interest-related pursuits. Connected learning is an emerging model for understanding youth's technology-supported interest-related pursuits, characterized by six principles (Ito et al., 2013). We sought to measure youth's experiences of these principles in the context of their particular pursuits, with the aims of (a) investigating the extent to which experiences of the six principles of connected learning can be measured validly and reliably, and (b) considering how the connected learning model might be revised in light of results of a measurement study.

Recent Research on Technology Supports for Interest-Related Pursuits

New technological infrastructures have made it possible for young people to discover and develop an ever-widening array of interests and to connect to others who share their interests and engage in a range of activities. For example, young people today can find people online who share their interest in a popular film or television program and develop elaborate "fanfiction" texts for others to read and critique (Black, 2005). Young people are not just using technology to discover interests by connecting to online communities. Other young people are using new technologies to support their participation in politics (Garcia & Morrell, 2013; Goldman, Booker, & McDermott, 2008; Jenkins, 2012). Still others are using technology to develop skill in creative and artistic pursuits (Polman et al., 2010).

A notable characteristic of many of these pursuits is that young people engage in them across multiple settings. For example, a girl interested in the game *The Sims* may play the game at home with friends, online with virtual partners, and they may meet up with others outside the game context to socialize and discuss strategies for "modding" the

game both in person and through social media or online communities (Gee & Hayes, 2010). In many cases, the opportunity to engage across settings is by design: developers of games like *The Sims* aim to support engagement across multiple media (Jenkins, 2010).

The ubiquity and popularity of these technology-supported opportunities among youth has gained the attention of educators and educational researchers, and there is now a growing body of research that explores the potential of supporting learning across settings through educational game play, digital media production, and digital activism (Burke & Kafai, in press; Gee, 2007, 2010; Middaugh & Kirshner, 2015; National Research Council, 2011). Much of the research has taken the form of compelling case studies and rich ethnographic accounts of how young people leverage new digital tools to pursue interests across settings (for a representative collection, see Ito, 2009). At present, however, there is a need for quantitative measures of young people's experiences of technology-supported and interest-related learning opportunities that could be used for purposes of research and evaluation across different types of educational programs. Through the use of such measures, researches and evaluators can make comparisons of experiences and opportunities across sites and activities.

Concern about equity is another reason to invest in efforts to measure young people's experiences of technology-supported, interest-related learning. Access to and participation in interest-related learning opportunities online are shaped by youth's social networks and by class, culture, and nationality (Ünlüsoy, de Haan, Leander, & Volker, 2013). Caregivers in upper income households are able to spend more for their children on resources and structured learning opportunities that take advantage of new

technologies than caregivers in lower income households (Ito et al., 2009; Watkins, 2011; Zickuhr, 2013). Large-scale survey studies can explore the degree to which access to opportunities to pursue interests across settings is equitable, and such studies can also help identify programs that are helping to expand access to youth from nondominant communities. They may help, too, to identify sites for more in-depth study, where young people from lower income families are exhibiting resourcefulness with the limited access they have to new technologies (cf., Schwartz & Gutiérrez, 2013).

The Current Study

The purpose of the current study was to develop a measure of youths' experiences of *connected learning*. Connected learning is an emerging, synthetic model of learning whose principles are consistent with those of positive youth development (Catalano, Berglund, Ryan, Lonczak, & Hawkins, 2004), sociocultural learning theory (Engeström & Sannino, 2010; Gutiérrez, Baquedano-Lopez, & Tejada, 2000; Lave & Wenger, 1991; Rogoff, Baker-Sennett, Lacasa, & Goldsmith, 1995), and findings from ethnographic studies of young people's interest-related interactions with digital media (Ito, 2009; Salen, 2008). Connected learning is evident when "a young person is able to pursue a personal interest or passion with the support of friends and caring adults, and is in turn able to link this learning and interest to academic achievement, career success or civic engagement" (Ito et al. 2013, p. 4).

Digital media plays a significant role within connected learning. In particular, practices that employ digital media can foster self-expression, link home, school, community, and peers, broker connections based on shared interests, and expand youths' access to new activities (Barron et al., 2010; Barron, Martin, Takeuchi, & Fithian, 2009;

Buechley, Peppler, Eisenberg, & Kafai, 2013; Kafai & Peppler, 2011). As we detail in the section on our sample, these media-supported practices take place in and across a range of settings, including schools (Salen, Torres, Wolozin, Rufo-Tepper, & Shapiro, 2011), homes (Dugan, Stevens, & Mehus, 2010; Stevens, Satwicz, & McCarthy, 2008), and community organizations such as libraries (Barron et al., 2014).

In this study, we sought to develop validity evidence for a measure of youths' experiences of connected learning. Specifically, we asked:

1. Can youths' experiences of the six principles of connected learning be measured validly and reliably?
2. How does information obtained from the survey instrument compare with qualitative accounts from youth?
3. How can the model of connected learning be refined in light of evidence from the development of this measure of connected learning?

Approach to Instrument Design

In this research, we employed an iterative, *construct-centered* approach to developing a measure of youths' experience of connected learning. Such an approach begins by elaborating upon the definition of the construct, sometimes in ways that articulate qualitatively distinct levels of the construct (Wilson, 2005). In our study, we created specific *construct maps* that described successive levels of depth of experience for each of the principles of connected learning. The elaborated construct definitions then served as a basis for item design. For this effort, we employed tools and structures afforded by evidence-centered design (ECD; Mislevy & Haertel, 2006; Mislevy, Steinberg, & Almond, 1999), a type of construct-centered approach that provides specific

means for defining key features of items. The next step in construct-centered approaches is to use psychometric models to administer the items to an appropriate sample of youths, and evaluate the extent to which the first three steps have been successful. Such models include but go beyond measures of reliability from classical test theory (e.g., Cronbach's alpha); in our case, these models allow us to investigate systematically whether item responses conform to our hypotheses on the ordering of levels of experience as represented in our construct maps.

Following the first iteration of construct mapping, designing items, and evaluating the instrument, the feedback gained and lessons learned were leveraged to make revisions to the construct maps and rewrite many item. We then administered the revised survey to a second sample of youths and again employed psychometric models were to help evaluate the extent to which the revisions had resulted in improvement of the measure.

Target Constructs: The Six Principles of Connected Learning

Ito and colleagues (2013) identified six core principles of a connected learning experience. Youths should experience connected learning as: (1) interest powered; (2) peer supported; (3) academically oriented; (4) production centered; (5) shared in purpose; and (6) openly networked. Each of these is described in further detail below and defined in Table 1 below. At present, the model of connected learning does not specify what constitutes a deep experience of a particular principle, nor does it specify which elements must be present for an experience to count as connected learning. Our study aims to advance our understanding of the former, by elaborating each of the constructs into different levels of depth of experience of connected learning.

Insert Table 1 about here

Interest powered principle. Interest powered experiences are ones that are centered or organized around a participant's interest and that allow a young person to develop knowledge or skill related to that interest. As such, the experience is one in which interest catalyzes the search for knowledge, and knowledge in turn helps to deepen a person's interest in a particular pursuit.

Relevant observable behaviors: Experiencing a pursuit as being interest powered is expressed via participation in the pursuit across multiple settings, seeking out new settings in which to pursue the activity, and discovery of new related interests.

Peer supported principle. One important meaning of the term "connected" in connected learning is that it characterizes the way a young person experiences supportive connections to others as they pursue particular interests. Young people who experience pursuits as "peer supported" fluidly contribute, share, and give feedback to one another. Peers in a peer-supported experience also provide encouragement and support for successful movement across different social worlds.

Relevant observable behaviors: Experiencing a pursuit as being peer supported is behaviorally expressed via reports of peers brokering access to new learning opportunities related to the pursuit, and reports of peers assigning tasks or responsibilities in activities.

Academically oriented principle. Connected learning recognizes the importance of academic success for intellectual growth and as an avenue towards economic and political opportunity. Thus, one meaning of "connected" pertains to strong, mutually reinforcing institutional (e.g., from school, family) supports about the importance of

intellectual growth and academic achievement. What particularly matters are the ways that peers and adults recognize the value of school, encourage school success, and provide recognition for accomplishment in school from longitudinal analyses of youth development indicate that out-of-school pursuits, such as sports, can in fact enhance young people's success in school (Weisman et al., 2003).

Relevant observable behaviors: Experiencing a pursuit as being academically oriented is expressed via teachers displaying awareness of the skills developed in the pursuit (whether they are developed in or outside of school), and via students reporting that they feel supported by teachers.

Production centered principle. Connected learning is designed around production, that is, around providing tools and opportunities for youth to produce, circulate, curate, and comment on media. These practices, importantly, depend on advances in social media and easily accessible digital authoring tools that make media more participatory, blurring the lines between producers and consumers of content. Production centered experiences may include designing games, writing fan fiction, and producing documentaries and podcasts not just for themselves but also for a broader audience. These productions are often oriented toward external audiences, and they may include efforts to critique existing media portrayals of youth, to resist injustice, or to work for social justice in their communities.

Relevant observable behaviors: Experiencing a pursuit as being production centered is expressed via critiquing and producing artifacts, and/or creating performances with the purpose of reaching others with a message of how to make a difference in the world.

Shared purpose principle. An experience of connected learning is one in which youth participants have a say in the purposes and structure of activity. Such activities are uncommon in contemporary Western cultures, because for much of their day, children and youth do not participate in so-called adult activities as co-participants but spend most of their time in child-focused activities (Rogoff, 2003). Shared purpose also entails the side-by-side participation of adults and youth in authentic, shared endeavors. Within these endeavors, adults can be guides or mentors, or they can be co-participants in joint work to change conditions in communities. The image of joint work—in which youth and adults have a vested interest in the outcomes of youths' activities and provide not only support but also help make decisions—captures well the principle of "shared purpose" in connected learning.

Relevant observable behaviors: Experiencing shared purpose within a pursuit is expressed via reports of a strong sense of a common purpose, more equitable participation, and increased opportunities for youth to lead and contribute meaningfully to the activity.

Openly networked principle. Digital media are essential tools for the openly networked principle. To say that a young person experiences a pursuit as openly networked is to assert that resources, tools, and materials for learning are diverse, accessible, and discoverable across the different settings of a young person's life. This principle points toward the possibility that these tools also serve as "boundary objects" (Star & Griesemer, 1989) that help connect and coordinate people, activities, and settings. When functioning well, these tools make up largely invisible layer of infrastructure that supports youths' interest-related pursuits, regardless of where they are physically.

For learning resources to be accessible to youth often requires that adults help broker access to those tools. Thus, a key aspect of the openly networked principle is access to adults with sufficient knowledge of available resources and an inclination to help facilitate access to those resources.

Relevant observable behaviors: Experiencing a pursuit as being openly networked is expressed via reports of access to diverse learning resources, tools, and materials that youth perceive to be necessary for them to engage in the pursuit in the settings where they do or would like to pursue it.

Sample

The data we use to address our research questions come from two field tests of the survey, conducted in spring 2013 and spring 2015. The first study sample was comprised of 479 youth aged 13-17 from 19 different program sites that provide opportunities for youth to pursue activities that reflect many of the principles of the current model of connected learning. The second sample was comprised of 258 students from the same program sites. The great majority of youths were from US based programs; however, there were also youths from South America, Australia, Asia and Europe. The average age of youth in the sample was 15. Just under half (46.5% of the first sample and 44.6% of the second sample) were female. The sample was ethnically diverse: 26.2% identified as Mexican, Mexican American, or Chicano; 21.6% as African American; 14.6% as White; 11.1% as other Hispanic or Latino; 10% as Asian or Asian American; and 5% as Native American. In the US, youths came from zip codes reporting median household incomes between $14,586 and $192,250. The median income households in these zip codes was

$46,178, which is slightly below $51,017, the estimated 2012 median income of the US (DeNavas-Walt, Proctor, & Smith, 2012).

Each of the 19 programs dedicated at least one of their staff to serve as the on-site survey administrator. To better understand youths' responses and the contexts in which connected learning occurs, we also surveyed the program support staff at each site. We received 21 responses from a total sample of 23 support staff surveys. Some sites had multiple staff assisting with survey administration, which accounts for the difference in programs and survey respondents. Table 2 below summarizes key features of the offerings across the 19 programs in the survey sample, developed from surveys conducted of staff in each of the programs.

Insert Table 2 about here

Developing the Measures

We developed constructs maps to help facilitate the conceptualization of experiences of the connected learning principles as continuous quantitative attributes and elaborate on the observable behaviors associated with variation in these attributes. A construct map is a particular type of theory representation, which involves conceptualizing the construct as a continuum along which individuals may be ordered (Wilson 2005). Construct maps also express an ordering of the observable behaviors (i.e., items), in this case representing hypotheses about the depth with which an individual must experience each of the connected learning dimensions in order to be likely to endorse an item (with some items being easier to endorse than others). For each of the six principles, we created maps that

described how an individual might experience that principle at varying levels of depth. For example, for the peer supported principle (as shown in Figure 1), we hypothesized that the shallowest or most minimal form of experience was that youths believe that their peers provide limited or no peer support for participation in their activity of choice and the deepest or richest experience of peer support is when youths' believe that their peers help broker access to new opportunities to deepen and pursue interests.

For each level of the construct we identified or created items that should indicate that youth responding positively to those items should be at that level of the construct or higher. The application of the Rasch model (Rasch, 1960) allows us to simultaneously test our hypothesis about the levels and the items mapped onto those levels.

Insert Figure 1 about here

Characteristics of the administered survey. As noted earlier, identifying an activity likely to elicit connected learning is a key to the survey instrument. The question used in the final survey to get at this activity was:

> *Can you think of an activity you do here at [Program or Community Name] that you really enjoy and you are getting better at the more do it?*
>
> *Yes. What is that activity? Please type in only one activity.*
>
> *No. What is the activity that you spend the most time doing while here? Please type in only one activity.*

The activity from this question was used throughout the entire survey: all questions were phrased in relation to this particular activity, except for questions about youths' backgrounds.

Survey administration. Once the research team finalized the list of participating programs, we conducted webinar trainings with volunteers from the program staff. Volunteers were trained on how to access the web-based survey, log users in, and submit the survey, as well as how to work with youth to curate a list of activities that would be appropriate for the scope of the survey.

Surveys were administered and collected over a two-month period during spring 2013; this procedure was repeated during the second iteration in spring 2014. In addition to age requirements, youth needed to have been involved in the program for no less than two months. This was to ensure that they had received adequate exposure to the activities in question such that they could make evaluative statements. All responses were collected using SNAP survey software. Upon completion of the survey, youth were provided with a gift card in recognition of their time.

Comparison to evidence from interviews. We also gathered data from interviews as part of the study, to triangulate against the evidence produced by the survey. Our purpose was to gain insight into how youth's experiences as reported in interviews compared to experiences as reported in the survey. Our comparisons focused on five sites that volunteered to participate in youth-led research at their own sites. Eighty-two semi-structured interviews were conducted by youth at each site. These youth were participants at the site and volunteered to recruit and interview peers for the study. The youth researchers also adapted an interview protocol developed by the research team for

eliciting details about long-term, interest-driven pursuits, the development of expertise in an area of interest to them, and the formation of new social ties through participation in connected learning.

Two researchers working independently systematically coded these interviews via a multi-step process, which included the development, testing and refinement of codes throughout a series of coding summits. The coding process was largely inductive, rather than theory-driven, so as to complement the more theoretically-driven survey; in that way, we hoped to identify salient themes (Lemke, 1983) with respect to youth's interest-driven pursuits that might suggest needed additions or refinements to the connected learning model. The coding scheme for descriptor and thematic codes was iteratively refined until at least 80 percent agreement was achieved for each code between pairs of independent raters (as calculated using Cohen's kappa; Cohen, 1960).

Analysis of Field Test Results

As discussed previously, we initially hypothesized that each of the six dimensions of "experiences of connected learning" could be modeled as a continuous quantitative construct, and could be measured via responses to survey items. Additionally, the six initial construct maps imply more specific hypotheses concerning the ordering of the items (e.g., which items should be harder or easier to endorse).

A partial credit Rasch model (Masters, 1982; Rasch, 1960) was fit to the initial wave of survey response data as a method of investigating these hypotheses, and again to the data from the second wave. The Rasch model can be viewed as formalizing the hypothesis that variation in a continuous quantitative attribute of persons is causally, but stochastically (i.e., not deterministically) responsible for variation in their responses to

survey items. In our case, the Rasch model tests our initial hypothesized levels of experience for each of the six principles of connected learning.

Evaluation of overall model fit (i.e., the extent to which the actual responses patterns for *each dimension* conform to what would be expected if the model is true) provides feedback relevant to the hypothesis regarding the measurability and quantitative structure of each dimension, and evaluation of individual item parameter estimates and item fit estimates (i.e., the extent to which response patterns for *each item* conform to model expectations) provides feedback relevant to the item-response-specific hypotheses entailed by the construct maps. All models were fit using ConQuest v2.0 (Wu, Adams, Wilson, & Haldane, 2007); all parameters were estimated via marginal maximum liklihood.

In addition to the six unidimensional Rasch models, we fit a multidimensional Rasch model to the data from all six principles simultaneously. For all models, we compared item parameter estimates (which can be visually represented using a Wright map, available upon request) for each dimension to the relevant construct map, and instances of severe deviation from construct map expectations were flagged for further review. Additionally, we examined item fit (i.e., infit and outfit mean-square) statistics, beginning with those showing the most severe misfit (e.g., outside the tolerance range of 0.75 to 1.33 recommended by Adams & Khoo, 1997) and progressively moving in to the items with less severe misfit. We also inspected the mean estimated person location for each possible item response with an eye for instances of "reversals" (i.e., in which a response hypothesized to be associated with a higher level of the construct was estimated to be

associated with lower average person location than other responses). Finally, we examined the person-separation reliability of each scale.

We then discussed these initial results internally, triangulating interpretations with results from cognitive interviews from our pilot sample and theoretical discussions with other scholars interested in connected learning. Rather than eliminating misfitting items out of hand, we regarded instances of misfit as potential falsifications of the hypotheses (both construct-level and item-level) implied by the construct maps. Depending on the nature of the misfit, we pursed one or more of several options: (a) revision of the definition of the relevant dimension of connected learning, (b) revision of the construct map (which could take a variety of forms), (c) rescoring of the item, (d) temporary removal of the item with intent to revise in a future iteration of instrument design, and finally (e) permanent removal of the item from the survey.

Comparison to interview data (Question 2). To compare interview and survey data, we focused on site-level comparisons. We did so for both theoretical and practical reasons. Theoretically, we sought to analyze the different contributions that survey and interview data might make to an understanding of site-level experiences of connected learning. We also sought to identify aspects of youth's experiences of the principles of connected learning that might not be adequately reflected in the survey questions. Practically, we focus on site-level comparisons, because it was not possible for us to link the two data sources at the individual level, due to human subjects agreements. Two different research teams collected the data, but the inter-institutional agreement regarding data sharing prohibited sharing unique identifiers that would have enabled linkages across the data.

The comparison of the two data sources focuses on one principle, the *peer supported* principle, because this particular principle was salient in the interview data analyzed. For each site, a researcher on the team identified the most frequent thematic codes to identify the most salient youth experiences with respect to this particular principle. For each site, case descriptions were developed for these sites, and contrasts among the site identified through a matrix. We then compared these to both scale scores (for the peer supported principle) and individual items relating most closely to the codes. We present summaries of these findings in the results section below.

Results

Measurability of the Principles

Below, we present the results of our analyses of items related to each of the six principles of connected learning. We present them roughly in the order of what we consider to be the least promising evidence in support of the measurability of the principle to the most promising. Table 3 below summarizes estimated reliabilities associated with scales for each principle.

Insert Table 3 about here

Academically oriented principle. The seven items designed to measure the academically oriented principle largely failed to conform to model expectations. The empirical ordering of the item severities bore little if any correspondence to the expectations of the construct map, and the overall scale reliability was estimated as 0.22. We inspected misfit patterns closely, but the patterns appeared to be essentially random. We interpreted these results as a falsification of the overall hypothesis of the

measurability of an academically oriented construct, at least as this construct is currently conceived. Accordingly, this dimension was dropped from the second version of the measure.

Production centered principle. The seven items designed to measure the production centered principle all displayed acceptable fit to the Rasch model, and the empirical ordering of these items was generally in line with the expectations of the construct map. One exception to this was an item that asked youths about how often they used professional tools in their work, which were empirically much easier to endorse than had been expected. Additionally, one reverse-coded item (asking whether a youth "use[d] tools mainly designed for children and youth") displayed "reversal" in mean person location and was estimated to be the most severely misfitting item. We deemed this item unsalvageable and eliminated it. The overall reliability was estimated as 0.49.

After discussion, revisions were made to the construct map, and several items were re-written for the second version of the measure, which included a total of six items. The empirical ordering of items was now consistent with the construct map and all items displayed acceptable fit, with the possible exception of a question asking whether students used tools that professionals used. The estimated reliability improved to 0.79. We interpreted these results as evidence that significant progress has been made, though more item development work—and probably theoretical work—is still needed.

Shared purpose principle. We designed ten items to measure the shared purpose principle. Four of these were dichotomously-scored (endorse/not-endorse) items (e.g., whether the youth "had had an opportunity to use [his or her] judgment about a decision"), and six were statements about a youth's perception of their peers (e.g.,

"everyone is trying to achieve the same goals") with Likert response options (e.g., "strongly disagree," "disagree," etc.).

A fairly large number of items failed to display adequate fit to the model. Specifically, the Likert items displayed overfit the model (i.e., displayed less randomness than expected), while the non-Likert items displayed often underfit the model (i.e., displaying more randomness than expected). The empirical ordering of the items was roughly in line with theoretical expectations.

Team discussion failed to yield a consensus regarding the proper reaction to these findings. We decided that two Likert items designed to measure the peer supported construct more naturally fit with the shared purpose construct ("when someone who engages in the activity does really well, everyone is happy," and "people in the activity want everyone to be able to pursue what they are interested in"). We added in these items and re-estimated the model; while the evidence of method effects remained (as expected) the two new items displayed good fit and empirical ordering in line with theoretical expectations. The reliability was estimated as 0.79 for the scale linked to this principle.

In the second version of the measure, the items were retained with fairly minimal modifications. The finding regarding overfit of Likert items and underfit of non-Likert items was replicated. The overall reliability was estimated as 0.83. In the absence of a resolution to the issue of fit, it is difficult to draw a strong conclusion about the measurability of the shared purpose principle, despite strong evidence of the scale's reliability. As with the other scales, future work will need to clarify the nature of the theoretical connections between variance in the construct and variation in the particular kinds of responses elicited from youths.

Openly networked principle. The twelve items initially designed to measure the openly networked principle fell into two distinct groups: the first group was chiefly about whether the products of a youth's work was available to others, while the second group was chiefly about whether the youth had access to relevant technology. When we fit a unidimensional model to all twelve items, the items in the first group displayed extreme underfit while the items in the second group displayed extreme overfit; this could be interpreted as evidence that the two groups of items fail to measure a common construct. Additionally, the empirical ordering of item severities showed several instances of inconsistency with the expectations of the construct map, particularly for the first group of items.

In light of these results, we dropped the first group of items from further analysis, and we revised slightly the construct map for the remaining items. We again estimated the Rasch model; the empirical ordering of the items was now much more closely in line with model expectations, and the fit statistics were all in an acceptable range. The reliability of this scale was estimated as 0.61.

In the second version of the measure, eight new items were written regarding the ease or difficulty of finding information and other forms of support from others (e.g., "it's easy for me to find people who share my interests in the activity," with the options "true for me" and "false for me"), along with revised versions of the six items pertaining to access to technology. One item displayed extreme underfit; this was determined to be due to confusions resulting from the wording of the question. Otherwise; items mainly conformed to model expectations; the reliability was estimated as 0.80. We interpreted

these results interpreted as tentative supporting evidence in support of the hypothesized measurability and structure of an openly networked construct.

Interest powered principle. We initially designed eight items to measure the interest-powered principle. Of these, six were behavioral statements with Likert response options; the other two were (a) an item that pertained to the number of settings in which a youth reported pursuing activities related to his or her primary interest, and (b) the number of settings in which a youth had looked for additional opportunities to pursue their interest.

The empirical ordering of the items was consistent with theory-based expectations. The two non-Likert items underfit to the model. The most plausible explanation for this finding seemed to be the dramatic difference in response options (i.e., selecting specific activities versus responding on a Likert scale); thus this could be interpreted as a method effect. The reliability of this scale was estimated as 0.77.

Slight modifications were made to several items and a new item was added in the second version of the measure. All items displayed acceptable fit; the overall reliability was estimated as .75. Taken in whole, we interpreted this as tentative evidence in support of the hypothesized measurability and structure of an interest powered principle.

Peer supported principle. The sixteen items designed to measure the peer supported principle initially included ten dichotomous (endorse/not-endorse) items regarding peer support (e.g., “a friend or peer helps me find information related to my interests”) and six Likert items regarding the youth’s perception of their social environment (e.g., “when I get stuck doing the activity I can get helpful suggestions from someone about how to solve the problem”). When a Rasch model was fit to the data, all

ten of the non-Likert items displayed severe underfit, and the Likert items displayed severe overfit. These results could be interpreted as indicating that the two types of items measure distinct constructs, or that local item dependence is induced in each item set due to common item format (i.e., a method effect). Based on triangulation with cognitive interviews and theory, we judged the latter interpretation to be more plausible; furthermore, youths generally seemed to respond more thoughtfully and deliberately to the non-Likert items. Additionally, it was discovered that an item asking whether "a friend or peer buys or gives me things I need to help me pursue my interests" was very seldom endorsed by anyone, whereas an item asking whether "a friend or peer gives me advice related to my interests" was more commonly endorsed than expected. The reliability of the scale was estimated as 0.67.

In the revision, a new item was written asking youths to identify persons who "encourage you to participate in this activity." Unfortunately, this item did not fit the model, possibly due to formatting issues. Apart from this, the items on the second version fit the model well; the reliability was estimated as 0.86. Taken in whole, we interpreted these results as tentative evidence in support of the hypothesized measurability and structure of a peer supported construct.

Multidimensional models. Following the specification of models for each construct individually, a multidimensional model was fit to the full data set (given the revisions yielded from the work described above). This model allowed the estimation of inter-dimension correlations, disattenuated for measurement error. For the second version of the measure, the estimated correlations ranged from .33 to .72 (Table 4). This was in line

with expectations; also, importantly, there was no indication that any of the features were so highly associated as to be considered empirically redundant.

Insert Table 4 about here

Comparison to Evidence from Interviews: Peer Supported Principle

Site-level comparison of scores on the peer supported principle to evidence from peer interviews suggest some consistency between salient features elicited on the initial version of the survey and reports from interviews. For example, peer helping and assistance is the focus of several survey items, and "forms of help within the site" emerged as a frequently occurring descriptive code (52 instances). On the survey, youth were also asked about whether friends or peers helped to broker access to new opportunities to pursue interests, and in several interviews (9), youth indicated that friends had been critical in helping them to gain access to the site. This particular pattern of responses is consistent with what we might have predicted on the basis of our construct map: we would expect peer help within the site to be far more common than peers brokering access to new learning opportunities, something that would require far more investment of time on the part of a peer to do.

At the same time, friendships were salient in the interviews in ways that the survey did not elicit. For example, there were several instances (14) where youth mentioned making new friends as either a motivation for becoming part of activities at a particular site or as a salient consequence of taking part in site activities (11). In another three instances, youth cited interest in maintaining friendships as a reason for pursuing a particular activity at the site. Although we included a survey question about whether

peers encourage young people's named interest-related pursuit, we did not anticipate the need to measure how strongly friendship would figure as both motivation and consequence of participation in site activities (this, despite evidence from earlier ethnographic research that would have indicated the need to consider this fact; Ito et al. 2009). This particular difference between the qualitative and quantitative evidence suggested some potential refinements to both the peer supported principle definition and to survey items. In light of these, we included additional language and items about friends who co-participated in the focal pursuit on the second version of the survey, which may have contributed to the improvements in reliability and other psychometric properties discussed in the previous section.

Notably, some important differences across sites evident in the interviews were not evident in overall scale scores for the principles. We noted significant differences across sites in the patterns of peer support reported by youth through interviews. However, the site level means for the five sites that participated in the youth research were close to one another. These discrepant findings may be linked to the greater salience of friendship evident in interviews than anticipated by the study team, or they may due to other factors, such as sampling or method effects (peers interviewing peers with whom they may be friends).

Discussion

In this final section of the paper, we summarize key findings from our initial measurement research and point to future work planned to refine both our measures and the model of connected learning for interpreting youth's experience of interest related pursuits.

Measurability of Principles

We found supporting evidence, in various degrees, for the measurability of five of the initial six principles in the connected learning model. Of these, the shared purpose, interest powered, and peer supported measures worked fairly well initially, and were additionally improved in the revision; the empirical ordering of item responses was in good alignment with expectations based on the construct maps for each of these constructs. In addition, for all three constructs, there was good estimated reliability. For two constructs—the production centered principle and the openly networked principle—there was initially poor correspondence between item response patterns and the initial construct maps, and significant revisions to both the construct maps and items were made for the second version. The revised versions displayed significantly better fit and higher reliability estimates.

We found moderate correlations among the constructs, but they were not so large as to suggest the need to combine different principles for purposes of measuring the experience of connected learning. Substantively, we interpret this finding to mean that young people experience each of the principles in ways that are distinguishable from one another. Thus, to the extent that connected learning does encompass all six (or five) principles, we conclude that all of the dimensions should be measured on the survey.

Consistency of Quantitative and Qualitative Findings

In a preliminary analysis comparing quantitative and qualitative findings with respect to youth's experience of the peer supported principle of connected learning, we find some evidence that aligns closely with our initial expectations. Particularly encouraging is the finding in our interview analysis that friends' brokering access for

youth to new opportunities for engaging in their interest-related pursuit was especially salient for some youth, but also less frequent than more general forms of peer helping available in the setting. That is consistent with both our construct map and evidence from survey responses. Additional longitudinal research and qualitative evidence may be needed to understand if and when peer brokering results in a deepening of interest in a pursuit or another valued outcome, such as civic engagement or future orientation. We have some preliminary evidence from longitudinal analyses that changes in peer brokering are positively related to changes in future orientation among youth (Dadey, Penuel, & Maul, in progress). In addition, we will need to conduct additional analyses of other constructs, as well as analyses that compare responses of individuals.

Refinements to Model of Connected Learning

At present, a key conclusion of our initial measurement research is that the construct definition for the academically oriented principle needs to be revised. "Academics" encompasses a wide range of possible connections between an interest-related pursuit and school success, which may explain why there was such poor reliability for this scale. Items asked youth to report about how much their pursuit helped in different school subjects; however, some interest-related pursuits might be expected to help with academics in some subjects and not others. In addition, there are many more factors associated with success in school beyond deep engagement in an interest-related pursuit with a clear tie to academic subject matter. Given the importance to the model of connecting interest-related pursuits to success in work, civic life, in addition to school, reworking of the definition is warranted. We have developed a new construct map and associated items that are focused more sharply on youth's perceptions that their

experiences support their school-related activities and are currently testing these items in the field.

An extension of the construct definition of the peer supported principle may also be needed to encompass the variety of ways peers can support an interest-related pursuit. Encouragement and help are but two ways that peers matter, as indicated by our interview data. In particular, peers also play a significant role in motivating sustained engagement in a pursuit. Also, gaining new friends may be a valued (at least to youth) outcome of connected learning as well.

Conclusion

Measurement development studies like ours are important to advance not only our particular aims but also the field of digital media and learning. Many initiatives require the development of new measures of learning that target the particular learning goals of those initiatives, because standardized measures of achievement are poorly aligned to those goals (e.g., Shute et al., 2012). In addition to outcome measures, program-specific measures of implementation are needed, since claims about the impact of initiatives depend on evidence that programs have been implemented with some integrity to the principles underlying the model. Finally, additional measures like the ones we are developing as part of our study are needed that capture variation in young people's experience of learning with media across settings. With a variety of such measures in place, we can accumulate knowledge about when, how, and for whom innovations supported by digital media make a difference.

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Table 1.

Definitions of Constructs: Connected Learning Principles

Principle	Pursuit Is Experienced As…
Interest Powered	Centered on youths' own interests, enabling the development of knowledge and skill related to those interests
Peer Supported	Encouraged by peers who also provide help and feedback as part of their co-participation in the pursuit
Academically Oriented	Recognized by teachers and supportive of success in school
Production Centered	Involving making, production, or performance for an external audience
Shared Purpose	Adults participate alongside youth in a common endeavor in which youth have a say in the goals and structure of activity
Openly Networked	Well-resourced, in terms of access to tools and guidance in using tools needed for the pursuit

Table 2.

Program Offerings for Sample Sites (Number Offering by Frequency)

	Every week		*2-3 times a month*		*Monthly*		*Every few months*		*Annually*		*Hardly ever or never*	
Participate in community service	7	(32%)	2	(10%)	4	(19%)	2	(10%)	2	(10%)	4	(19%)
Organize and engage in political action	3	(14%)	0	(0%)	3	(14%)	5	(24%)	2	(10%)	8	(38%)
Write stories or poems (for print)	10	(48%)	3	(14%)	2	(10%)	0	(0%)	0	(0%)	6	(28%)
Write stories, blogs, or poems (online)	11	(52%)	3	(14%)	3	(14%)	2	(10%)	0	(0%)	2	(10%)
Put on dramatic performances	1	(5%)	1	(5%)	2	(10%)	4	(20%)	1	(5%)	11	(55%)
Learn basic computer skills	17	(85%)	1	(5%)	0	(0%)	0	(0%)	0	(0%)	2	(10%)
Play video games	8	(38%)	0	(0%)	2	(10%)	4	(19%)	0	(0%)	7	(33%)
Write fan fiction	8	(40%)	0	(0%)	4	(20%)	0	(0%)	0	(0%)	8	(40%)
Share strategies for game play with others	10	(47%)	0	(0%)	2	(10%)	0	(0%)	0	(0%)	9	(43%)
Design games	7	(33%)	3	(14%)	1	(5%)	0	(0%)	1	(5%)	9	(43%)
Design web sites	5	(24%)	2	(10%)	5	(24%)	2	(10%)	2	(10%)	5	(24%)
Design graphics/animations	9	(42%)	2	(10%)	3	(14%)	1	(5%)	1	(5%)	5	(24%)
Create/edit movies or mashups	12	(56%)	2	(10%)	1	(5%)	4	(19%)	0	(0%)	2	(10%)
Artwork/ Craft objects	11	(51%)	1	(5%)	0	(0%)	2	(10%)	1	(5%)	6	(29%)

Homework help	12	(58%)	2	(10%)	1	(5%)	0	(0%)	0	(0%)	6	(27%)
Doing science activities and experiments	7	(35%)	0	(0%)	1	(5%)	3	(15%)	0	(0%)	9	(5%)
Making collages/photo editing	15	(71%)	3	(14%)	1	(5%)	0	(0%)	0	(0%)	2	(10%)
Compose music	11	(51%)	2	(10%)	1	(5%)	2	(10%)	0	(0%)	5	(24%)
Play music	13	(62%)	0	(0%)	0	(0%)	1	(5%)	0	(0%)	7	(33%)
Play sports	5	(23%)	1	(5%)	1	(5%)	0	(0%)	0	(0%)	14	(67%)
Other	9	(56%)	0	(0%)	0	(0%)	0	(0%)	1	(6%)	6	(38%)

Table 3.

Reliability Estimates by Dimension

Dimension	**Final Reliability**
Academically Oriented (7 items)	0.22
Production Centered (6 items)	0.79
Shared Purpose (10 items)	0.83
Openly Networked (14 items)	0.80
Interest Powered (9 items)	0.75
Peer Supported (16 items)	0.86

Table 4:

Estimated Correlations Among Dimensions

	Shared Purpose	Production Centered	Peer Supported	Openly Networked	Interest Powered
Shared Purpose	1.00				
Production Centered	0.47	1.00			
Peer Supported	0.66	0.48	1.00		
Openly Networked	0.56	0.46	0.45	1.00	
Interest Powered	0.57	0.54	0.72	0.34	1.00

Note. All correlations are significant ($p<.01$).

Figure 1. *Construct Definition and Construct Map for Peer Supported Principle*

Construct Definition
Learning in the context of peer interaction is engaging and participatory. Research shows that among friends and peers, young people fluidly contribute, share, and give feedback to one another, producing powerful learning. Connected learning research demonstrates that peer learning need not be peer-isolated. In the context of interest-related activity, young people welcome adult participation. Although expertise and roles in peer learning can differ based on age, experience, and expertise, everyone gives feedback to one another and can contribute and share their knowledge and views.
Subconstructs
Sharing: Students share ideas and products with peers. *Feedback:* Feedback in CLEs refers to mutual, constructive response to contributions. A key quality of such feedback—when it results in learning—is that it is activity- rather than person-focused, and it is improvement- rather than performance-focused. *Sites of Peer Relationships:* Peer relationships can be characterized in terms of their "place," that is, whether contact is single-mode (e.g., online or face-to-face) or multimodal (e.g., both online and face-to-face).

Figure 2. *Construct Definition and Construct Map for Peer Supported Principle.*

Construct Definition: ***Among friends and peers, young people fluidly contribute, share, and give feedback to one another, producing powerful learning. In the context of interest-related activity, young people welcome adult participation. Although expertise and roles in peer learning can differ based on age and experience, everyone gives feedback to one another and can contribute and share their knowledge and views.***	
Level*	**Items**
Peers broker access to new opportunities to deepen and pursue interests.	A friend or peer signs me up for things that are related to my interests. A friend or peer gives me advice related to my interests. A friend or peer introduces me to people who know more about my interests. A friend or peer gives me responsibilities, jobs, or tasks related to my interests.
Peers provide strong support through teaching and helping within the activity.	A friend or peer teaches me new things. One or more friends encourage me to pursue the activity. A friend or peer helps me find information related to my interests. They let me teach them about what I know about my interests. They buy or give me things I need to help me pursue my interests.
Peers provide modest support through teaching and helping within the activity.	A friend or peer works with me on a project.
Peers provide limited or no peer support for participation in the activity.	No one encourages me to pursue the activity, I just like to do it.

*The highest level is represented at the top part of the construct map. We describe this level as the "deepest" form of connected learning, because opportunities for experiencing the principle are rich and diverse.