Measuring Children's Perceptions of their Use of the Internet: A Rasch Analysis
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# MEASURING CHILDREN'S PERCEPTIONS OF THEIR USE OF THE INTERNET: A RASCH ANALYSIS

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## Abstract

Measuring children's use of emerging technologies is prerequisite to determining the effect of such use on children's health, development and learning. The Ecological Techno-Microsystem provides a theoretical foundation upon which to select test items appropriate to the measurement of children's self-reported use of the internet across home, school and community contexts. A 15 item rating scale was developed which included five items across the three environments, for example: 1) I use the internet at home; 2) I use email at school; 3) I instant message at home; 4) At home, I use the internet to play games; 5) I visit websites when I am at somebody else's house. Ninety children rated each of the 15 items on a four-category response scale. Individual item fit statistics confirmed that data from all 15 items fitted the model well. Differential Item Functioning, consistent with empirical evidence, suggested gender differences in patterns of internet use during childhood. Rasch analysis (i.e., Item Map) confirmed that children with the highest self-reported internet use scores on the 15 item rating scale affirmed the most difficult items, that is, the items to which the that fewest children responded in the affirmative.

## Introduction

Children's use of emerging technologies, as is historically the case (Quigley & Blashki, 2003), is of considerable concern to educators, child psychologists, researchers and policy makers (Hofferth, 2010). Description of the nature and amount of use of technology is prerequisite to determination of the developmental and educational consequences of such use (Greenfield & Yan, 2006; Rideout, Foehr, & Roberts, 2010). This is true with television viewing (Livingstone, 2009), computer use (Fiorini, 2010) and, recently, use of the internet (Johnson, 2010a).

Most commonly, children's use of the internet is determined in two ways; asking parents and asking children. For example, Roberts, Foehr and Rideout (2005) conducted "a nationally representative survey of 3rd to 12th grade students, designed to explore their access to and recreational (non-school) use of a full range of media, including . . . the Internet" (p. 5). Rideout, Vandewater and Wartella (2003) reported "a nationally representative random-digit-dial telephone survey of more than 1,000 parents of children ages six months through six years" (p. 2). Researchers with the Media Awareness Network (2006) obtained data from more than 5,000 students in grades 4 through 12 via in-class questionnaires which included selected-response items such as *What information would you give to register on a game site (e-mail, real name and address, neither).* Livingston and Bober (2005) collected internet use data by face-to-face interviews with 1,500 young people and pencil-and-paper questionnaires completed by parents. With all such data collection strategies, *perception* of use, as opposed to real use, was actually determined. Unfortunately, the validity of existing approaches to measuring such perceptions has not been systematically established. Correspondingly, the generation of survey or test items to determine the extent and nature of internet use during childhood has not been based on firm theoretical foundations.

## Theoretical Framework: The Ecological Techno-Microsystem

Child development is the consequence of biological maturation and environmental influences. From a developmental perspective, media is conceptualized as one of many environmental influences. Ecological theory provides a comprehensive view of environmental influences on development by situating the child within a system of relationships affected by multiple levels of the surrounding environment (Darling, 2007; Johnson & Puplampu, 2008). Bronfenbrenner (1977, 1979) organized the contexts of development into five nested environmental systems, with bi-directional influences

within and among systems. The *microsystem* refers to direct or immediate interactions (i.e., family, peers, media and school). The *mesosystem* is comprised of connections between immediate environments (e.g., home-school interactions). The *exosystem* includes settings that indirectly affect child development (e.g., parent's workplace). The *macrosystem* refers to social ideologies and cultural values. The *chronosystem* highlights the effect of time on all systems and all developmental processes. Ecological systems theory emerged prior to the digital revolution and the developmental impact of then available technology (e.g., analogue television) was conceptually situated in the child's microsystem because the child was in direct contact with the technology.

Presented in Figure 1, Johnson (2010b) recently proposed the *ecological techno-microsystem* which conceptualizes child social, emotional, cognitive and physical development as the consequence of ongoing reciprocal interactions between child characteristics and use of communication, information and recreation digital technology across home, school and community environments. Such a conceptual framework is useful in considering the complexity of internet use during childhood and the extent to which different uses of digital technology may have differing effects on learning and development (Greenfield & Yan, 2006; Hofferth, 2010).
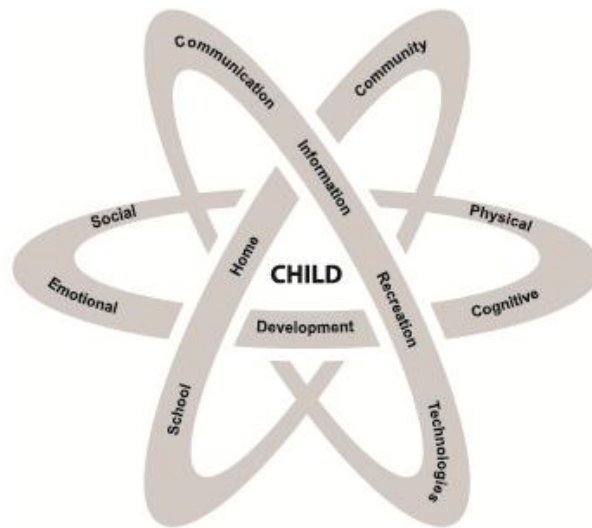


*Figure 1.* The Ecological techno-microsystem

The ecological techno-microsystem rings surrounding the developing child are conceptualized as fluid and the descriptors in the rings are for purposes of illustrations. That is, child developmental outcomes are typically organized in terms of domains which include social, emotional, cognitive, and physical. But child development is holistic (e.g., physical development includes brain changes and brain changes affect and are affected by cognitive development). Further, online behaviour is not meaningfully described as use of communication, information, and recreation digital technologies. Online behaviour "refers to organized (e.g., search) and unorganized (e.g., browse) interactions with both human (e.g., chat) and nonhuman (e.g., database) elements in online environments" (Johnson & Kulpa, 2007, p. 773). Theoretically, the ecological techno-microsystem provides a basis for the generation of test items appropriate to survey children's perceptions of their use of the internet across contexts of use.

## Research Objective

Reflecting the theoretical assumptions of the ecological techno-microsystem, the current research aims is to construct and test a parsimonious self-report measure of children's use of the internet at home, school and in the community.

## Methodology

The philosophical genre of hermeneutical phenomenology (Heelan, 1982) provided a perspective for the development of an invariant measure of child internet use. A medium (theory and instruments) was constructed a priori on the assumption it would display invariance when taken into the field. The qualitative differences between children (the variance in internet use), were expected to be *inscribed* on the instrument by the children. This is a scientific approach in which specification of a construct model based on previous research and theory precedes development of research hypotheses, instrument design, data collection and data analysis. Wright (1984) qualified the notion of scientific measurement as "what physical scientists mean by measurement requires an ordering system and the kind of additivity illustrated by physical concatenation" (p. 1). Physical concatenation is simplistically demonstrable by joining the ends of sticks to concatenate length, or by piling bricks to concatenate weight (Campbell, 1920). In order to create a scale that measures a variable in accord with the theoretical requirements for measurement, Wright and Masters (1981) identified the requirements for measurement. These included:

- Each item should be evaluated to see whether it functions as intended.
- The relative position (difficulty) of each valid item along the scale that is the same for all persons should be estimated.
- Each person's responses should be evaluated to check that they form a valid response pattern.
- Each person's relative score on the scale should be estimated.
- The person scores and the item scores must fit together on a common scale defined by the items and they must share a constant interval from one end of the scale to the other so that their numerical values mark off the scale in a linear way.
- The items should remain similar in their function and meaning from person to person and group to group so that they are seen as stable and useful measures.

The Rasch Model (Rasch, 1960) is a measurement model and when data fit the model, the preceding theoretical requirements are met (Andrich, 1982, 1985, 1988a, 1988b). Data-to-model fit is tested by estimating fit statistics and generating graphical displays of item and person performance.

### Rating-Scale Administration

For this study, the instrument of data collection was a child self-report rating-scale. The components and structure of the construct model were applied to write 15 rating-scale items (Table 1). In addition to the rating scale items, data were collected on demographic variables including the child's gender, parent employment and parent level of education.

Parents of children in third through sixth grade attending an elementary school in western Canada were asked to allow their children to complete a rating scale on internet use and complete a brief questionnaire which included demographic queries Ninety children (37 males and 53 females) returned signed research participation consent forms. Twenty-one of the children were in third grade, 22 were in fourth grade, 17 were in fifth grade and 30 were in sixth grade. The youngest child in the sample was 8.3 years of age and the oldest child was 12.9 years of age (mean 10.7 years). The majority of parents (87.5) described their family as traditional, 10% described their families as blended and 2.5% indicated single-parent family type. All fathers and 71.2% of mothers reported being employed (full-time or part-time).

Children responded to each of the 15 rating-scale items on a four-category response scale – never or hardly ever (scored 0), once or twice a month (scored 1), once or twice a week (scored 2) and every day or almost every day (scored 3). Data were entered into the computer program RUM2030 (Rasch Unidimensional Measurement Models; RUMMLab 2007). Summarized in Table 2, six estimations were performed to test six properties of the data. Since the data were from rating-scales (polytomous data), the Extended Logistic Model of Rasch (Andrich, 1988a) was used.

Table 1. Internet Use Survey Items

| Home Internet Use |
| --- |
| I use the Internet at home. |
| I use email at home. |
| I instant message at home. |
| At home, I use the Internet to play games. |
| At home, I visit websites. |
| **School Internet Use** |
| I use the Internet at school. |
| I use email at school. |
| I instant message at school. |
| At school, I use the Internet to play games. |
| At school, I visit websites. |
| **Community Internet Use** |
| I use the Internet at someone else's house. |
| I use email at someone else's house. |
| I instant message at someone else's house. |
| I play Internet games at someone else's house. |
| I visit websites when I am at someone else's house. |

Table 2. RUMM Estimations and Respective Applications

| Estimation | Application |
| --- | --- |
| 1. Category Probability Curves | Testing whether the data fits the hypothesised order of the response scale categories |
| 2. Individual item fit statistics | Testing data-to-model fit for individual items |
| 3. Summary statistics | Testing whether the data for persons and items fit the measurement model |
| 4. Item Characteristic Curves - differential item functioning | Testing whether an item functions differently for particular groups of persons – e.g. boys and girls |
| 5. Item map | Comparing distributions of person scores and item difficulties |
| 6. Varimax location loadings - factor analysis of residuals | Testing whether the data are unidimensional |

## Results

### Category Probability Curves

Figure 2 shows the Rasch model estimations of the probabilities of children selecting either of the four response categories for Item 6 (i.e., *I use email at someone else's house*). The horizontal axis is child internet use and this is calibrated in logits (the logarithmic odds of responding affirmatively). Children with high internet use scores are located to the right of the zero and those with lower internet scores are located to the left of the zero. Curve 0 shows there is a high probability (0.99) that children with very low internet use scores (-4.0 logits) will select the *never or hardly ever* response-option. Alternatively, children with high internet use scores (8.0 logits) have a high probability (0.7) of selecting the *everyday or almost every day* response-option. However, this logical selection of response-options is not evident in the probability curves for the middle two categories. Children with an internet use score of 0.7 logits have an equal probability (0.30) of selecting *never or hardly ever* (Curve 0), *once or twice a month* (Curve 1) or *once or twice a week* (Curve 2). The children were confounded in their choice of categories which suggests the response scale should be simplified.

One approach to response scale simplification is by post hoc reduction of the number of response categories and combining data from two adjacent categories into one category. For example, combining never or hardly ever and once or twice a month data and once or twice a week and every

day or almost every day data. Item 6 data were amalgamated and the two new category probability curves were plotted (Figure 3). The new dichotomous response scale shows logical selection of categories in line with the internet use scores. Plotting the category probability curves for all 15 items showed another eight items elicited illogical responses. The procedure applied to Item 6 data was repeated for these eight items. Additionally, for consistency, the response scales for the other six items were also modified.
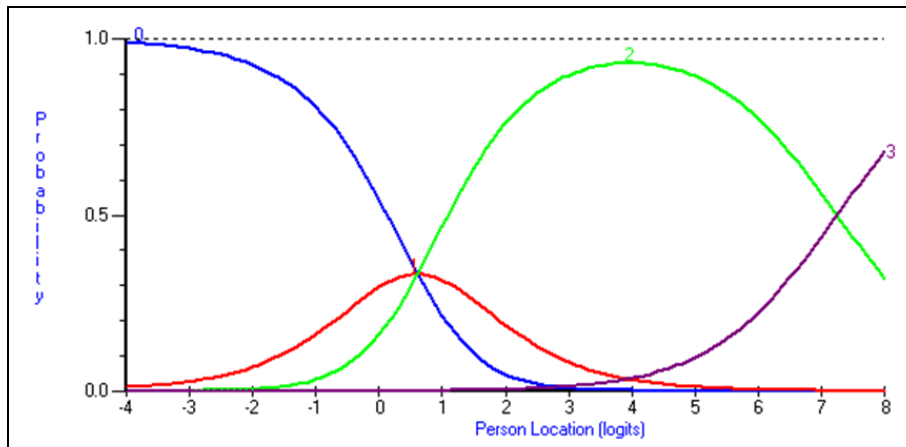


*Figure 2.* Category probability curves for item 6 – four categories
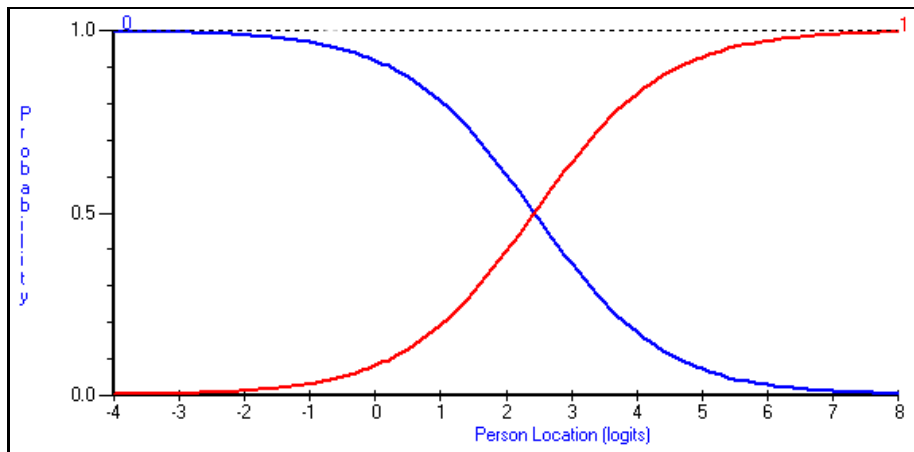


*Figure 3.* Category probability curves for item 6 – two categories

## Individual Item Fit Statistics

RUMM2030 generates Item Characteristic Curves for each item that plot the value for an item predicted by the Rasch model against the child internet use score. The Item Characteristic Curve for Item 4 (*I use email at home*) is presented in Figure 4. This display also plots the observed scores for three class intervals of children. These are the black dots in Figure 4. The observed scores are close to those predicted by the model because the data for Item 4 conforms to the requirements of the Rasch model. The data fit the model and the residual, the difference between the actual and predicted values is low. Data from all 15 items fitted the model well.

## Summary Statistics

RUMM2030 summarises the fit statistics for items and children, estimates item-trait interaction and calculates the person separation index. The distributions of the residuals were acceptable. The item-trait test of fit indicates the degree to which item difficulties are consistent across the scale measured, independent of the person abilities. The person separation index was good (0.70) because the child internet scores were spread across the continuum.
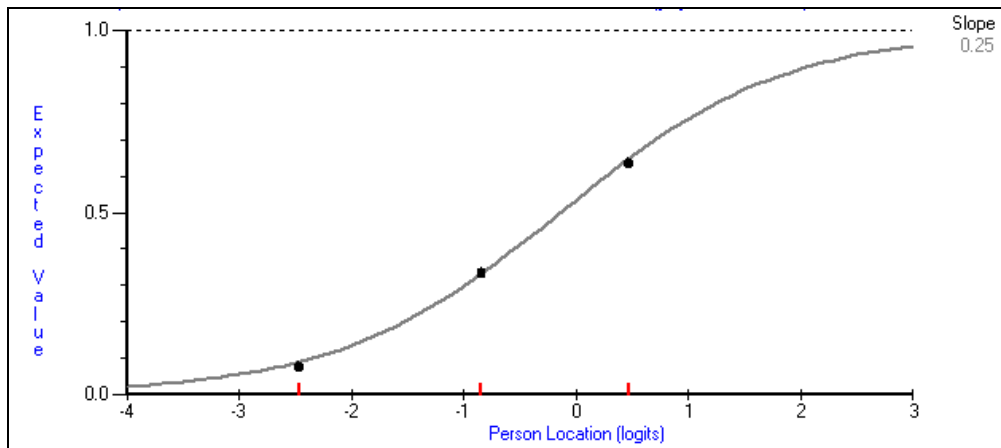
*Figure 4.* Item characteristic curve for item 4

## Differential Item Functioning (DIF)

The responses of children to each item should be a consequence of their internet use and not person factors such as gender or family background, unless the construct is sensitive to such individual characteristics. Children with the same level of internet use should respond similarly, irrespective of extraneous variables, although gender may not be an extraneous variable with respect to patterns of internet use during childhood (Johnson, 2011). The observed scores plotted on the Item Characteristic Curve display can be differentiated according to child membership in different groups (e.g. gender). The Characteristic Curve for Item 4 (*I use email at home*) is displayed in Figure 5 and the observed scores for males and females with similar internet use scores are plotted against this. The children were separated into three class intervals – children with internet use scores around - 2.5 logits, - 0.8 logits and 0.5 logits. For all three class intervals, the observed scores of the males were higher than females with the similar internet use scores. This phenomenon is termed *Differential Item Functioning* (DIF). While this differences could be due to a natural factors, the item is biased which has the potential to restrict generalising about internet use and gender.  Similar analyses of data from the other 14 items and other analyses testing for effect of parent employment and education level failed to reveal any DIF.
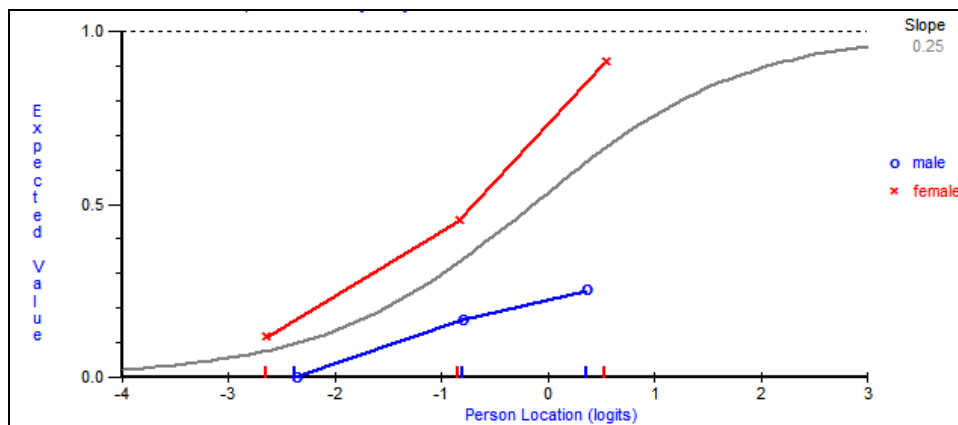


*Figure 5.* Item characteristic curve item 4 with gender plotted

## Item Map

Although the Rasch model enables person measures to be constructed that are not dependent on the specific items selected and for the difficulty of items to not be dependent on the sample of persons studied, it is possible to plot person scores and item difficulty estimates on the same scale. This enables examination of the targeting of items to test whether only the children with the highest

internet use scores can affirm the most difficult items and that these children are presented with items commensurate with their high level of internet use. The internet use scores of the children and the difficulties of the 15 items are plotted on the same logit scale in Figure 6.
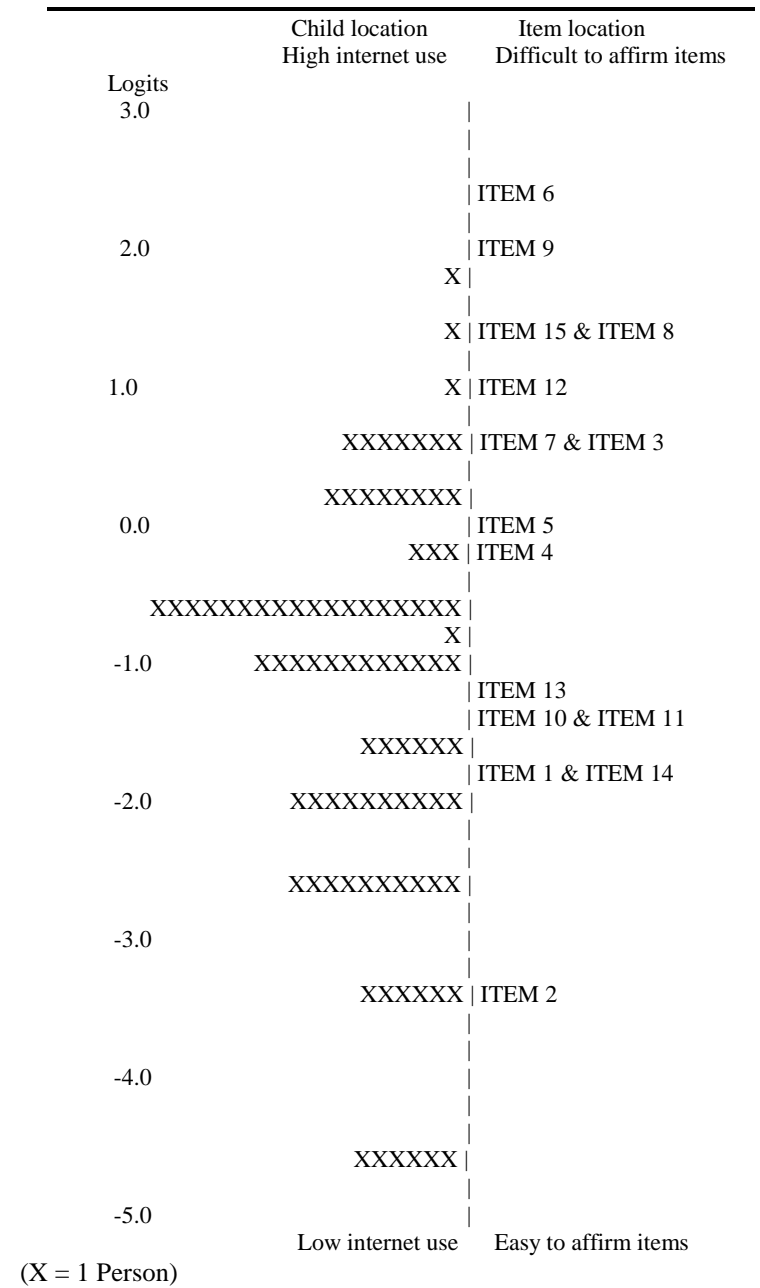
```
                        Child location          Item location
                        High internet use       Difficult to affirm items
            Logits
            3.0                         |
                                        |
                                        |
                                        | ITEM 6
                                        |
            2.0                         | ITEM 9
                                     X  |
                                        |
                                     X  | ITEM 15 & ITEM 8
                                        |
            1.0                      X  | ITEM 12
                                        |
                               XXXXXXX  | ITEM 7 & ITEM 3
                                        |
                              XXXXXXXX  |
            0.0                         | ITEM 5
                                   XXX  | ITEM 4
                                        |
               XXXXXXXXXXXXXXXXXX       |
                                     X  |
           -1.0         XXXXXXXXXXXX    |
                                        | ITEM 13
                                        | ITEM 10 & ITEM 11
                               XXXXXX   |
                                        | ITEM 1 & ITEM 14
           -2.0          XXXXXXXXXX     |
                                        |
                                        |
                        XXXXXXXXXX      |
                                        |
           -3.0                         |
                                        |
                          XXXXXX        | ITEM 2
                                        |
                                        |
           -4.0                         |
                                        |
                                        |
                          XXXXXX        |
                                        |
           -5.0                         |
                        Low internet use      Easy to affirm items
        (X = 1 Person)
```

*Figure 6.* Item Map for Children's Internet Use Items

The range of children's internet scores is wide (6.4 logits), showing the instrument is sensitive to differences in child internet use. The range of item difficulties is similarly wide and closely matches the distribution of child scores. The items targeted this group of children well. The most difficult item to affirm was Item 6 (2.4 logits) and the easiest item to affirm was Item 2 (-3.6 logits).

## Varimax Location Loadings - Factor Analysis of Residuals

The unidimensionality within the data and indeed the unidimensionality of the internet use construct, were examined by a factor analysis of residuals after the principal Rasch measure was extracted. There is a lack of correlation between the items when each item loads on only one component.

Varimax rotations were applied and none of the items loaded on more than one component. This lack of structure in the residuals is evidence of the instrument measuring a unidimensional construct, that is, child internet use.

## The Meaning of the Scale

Results of the current investigation provide support for the validly and utility of the 15 internet use items that measure children's perceptions of their use of the internet across home school and community for purposes of communication, information and recreation. The number and nature of response-options, however, do not appear meaningful to children. Indeed, the difference between *hardly ever* and *once a month* is not obvious. Correspondingly, the difference between *twice a week* and *almost every day* appears vague, particularly for young children. Scales that hope to adequately measure children's perception of their use of the internet might best include a limited number of response-options with clear differences between options (e.g., *never, sometimes, always*).

Identifying extraneous versus pertinent variables is an essential task in educational and psychological research. On the one hand, a measurement instrument should be equally valid for males and females. Nonetheless, when measuring height, for example, the instrument may be seen to be biased against females but, of course, such is not the case. On average and given a sufficiently large and random sample, females are shorter than males (Gustafsson & Lindenfors, 2004). With respect to the current investigation, DIF suggested differences between males and females in terms of email use. Gender differences to emerge from the current Rasch analysis suggest that boys who are heavy internet users are more likely to use email than boys who are light internet users and vice versa. This is not necessarily true of girls. The perception that boys primarily play games online is not supported by the Item Characteristic Curve for the rating scale item, *I use email at home*. Boys who are heavier internet users may have more varied use of the internet than boys who are lighter users. Parental employment and level of education did not exert influence on any of the 15 internet use items rated by children. This is reasonable since home and school access is virtually universal (Johnson, 2011).

Rasch analysis (i.e., Figure 5 Item Map) confirmed that children with the highest self-reported internet use scores on the 15 item rating scale affirmed the most difficult items, that is, the items to which the fewest children responded in the affirmative. In every case, the items that were the most difficult to affirm assessed community-based internet use (i.e., *at someone else's house*). Apparently, during middle childhood, it is unusual to use the internet at someone else's house to communicate including sending email messages and instant messaging. While still difficult to affirm, visiting websites and playing online games while at someone else's house appear more common during childhood than using the internet to communicate. Correspondingly, the easiest items to affirm assessed internet use at school, particularly the items *I use the internet at school* and *I visit websites at school*. Because such findings are consistent with reports of children's patterns of internet use (Hofferth, 2010; Johnson, 2010a, 2010b; Rideout et al., 2010), the validity of the 15 item rating scale of children's perceptions of their use of the internet is further established.

## Conclusion and Implications for Future Research

Reflecting the theoretical assumptions of the ecological techno-microsystem, the current parsimonious self-report measure of children's use of the internet at home, school and in the community was constructed and validated. As suggested by the ecological techno-microsystem, children use the internet for communicating, accessing information and playing games and such use of the internet varies across home, school and community environments. The proposed instrument included 15 easy-to-read items and few issues of child reading comprehension were evident during administration. Nonetheless, the four responses-options (*never or hardly ever*, *once or twice a month*, *once or twice a week* and *every day or almost every day)* appeared to undermine sound measurement. Subsequent research may manipulate the number of response-options, particularity in relation to testee age, to determine the number of categories that provide the most useful information.

Mobile technologies are increasingly replacing traditional PC connectivity in the lives of both children and adults throughout the industrialized world (Smith, 2011). "It is estimated that more than 90% of youngsters between 10 to 14 years of age have cell phones or routine access to them in many countries" (Lin, 2010, p. 232). From an ecological perspective, ubiquitous connectivity changes the nature of internet use. Children's community-based internet access may no longer be restricted by place (e.g., *at someone else's house*). As new technologies are developed and infiltrate children's lives, new tests to measure the use of such technologies must be developed and validated. Rasch analysis provides a particularly useful means of establishing valid measures of children's perception of their use of technologies.

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