Abstract

Tailoring STEM instruction based on student interest in specific STEM domains is one potential way to increase recruitment into the pathways towards STEM careers. To effectively tailor instruction, it is crucial that we can accurately and efficiently measure the existing interest of learners for the domain being studied, in a way that is consistent with current interest development research. In this paper, we present the Four-Phase Interest Development survey as a tool that can be easily adapted for use with multiple ages, domain, and contexts to measure learner interest. To support researchers and designers in utilizing this tool, we present findings from prior work, as well as from two new administrations of the survey (N = 159) for chemistry.

Testing the Four-Phase Interest Development Survey for Chemistry

There is a well-documented need to increase high quality entrants into the STEM workforce (National Academies Press, 2007), and we must encourage and motivate students to enter the “pathways” into these fields. This motivation will require (among other things) developing and maintaining interest in STEM areas (Katehi, Pearson & Federer, 2009). Tailoring STEM instruction based on student interest is one potential way to meet this need, but it can be difficult to identify each learner’s current interest in the domain in a way that goes beyond surface level measures of interest. Thus, there is a need for an efficient and versatile tool, based on current interest development research, to assess student interest. To address this need, we created and tested the Four-Phase Interest Development in Engineering Survey (FID-ES). In previous work, we found the FID-ES survey to be a valid and reliable measure of a student’s level of interest in engineering (Authors, 2015), and have begun to test the use of modified versions of the FID-ES to be used in other domains. In this paper, we present results from testing the Four-Phase Interest Development in Chemistry Survey (FID-CS) in two administrations of an online chemistry tutoring system. Our goals are to demonstrate the versatility of the FID-ES survey by evaluating the validity and reliability of the FID-CS and to discuss the utility of using the variations of the survey as a tool to facilitate tailored instruction to better promote interest development in a STEM domain.

Theoretical Framework

Current interest developed theory makes an important distinction between situational interest, which is state-based, context-specific, impulsive, and transitory; and individual interest, or personal interest, which is conceptualized as a context independent and enduring predisposition to reengage with a domain (Ainley, Hillman, & Hidi, 2002; Krapp, 2002; Schraw & Lehman, 2001). Hidi and Renninger’s (2006) Four-phase Model of Interest

Development (FPMID) further refines the situational-individual interest distinction into four progressive phases of interest: Triggered Situational, Maintained Situational, Emerging Individual, and Well-Developed Individual. Each phase in the FPMID is sequential and distinct, with each subsequent phase building off the previous. In this model, positive feelings (or affect) play a crucial role in triggering situational interest, but progressive gains in value and knowledge of the content become increasingly important to maintain situational interest and developed more stable individual interest in a domain. Renninger and Su (2011) provide empirically based descriptions of learner characteristics at each of phase of interest. These descriptive characteristics allow insight into measurable indicators of interest that go beyond surface level descriptors like enjoyment and positive affect, and are thus well suited for measuring interest in an accurate and reliable manner.

The Four-Phase Interest Development in Engineering Survey (FID-ES) was developed using the learner characteristics from the FPMID and is a useful tool in identifying the relative level of a learner’s interest in engineering. The FID-ES is a valid and reliable, 12 item, Likert-style survey, that asks students to rate their level of agreement with statements (e.g. “I always learn more about engineering on my own if I find it interesting.”) using a scale from 1 (*strongly disagree*) to 7 (*strongly agree*) based on six indicators of interest derived from the FPMID. Response scores from each of the 12 items are averaged to produce a single *interest scale score* ranging from 1 – 7. The FID-ES survey has been previously used to reliably measure interest in three studies: engineering for high school students ($\alpha = 0.89$; Authors, 2015a), high school students participating in an out-of-school robotics engineering club ($\alpha = 0.84$; Authors, 2015b), and K–12 students visiting a biomechanical engineering expo ($\alpha = 0.81$; Authors, 2017a). In each case, the distribution of FID-ES scores was found to be consistent with expectations for that population. That is, the robotics engineering participants had a mean score (*M* = 5.79, n = 13, σ = 0.67) higher than K–12 students (*M* = 4.17, n = 607, σ = 1.27), and both had higher mean scores than high school students (*M* = 3.23, n = 145, σ = 1.21). Our first modified survey was found to be a reliable measure (Cronbach's α = 0.81) of middle school aged learner interest in reading (*M* = 5.80, n = 8, σ = 0.62; Authors, 2017b), with each learner's interest scale score closely related to their phase of interest in reading (based on interviews). In this paper, we describe the results of the Four-phase Interest Development in Chemistry (FID-CS) survey, a modified version of the FID-ES survey to be used for evaluating interest in chemistry.

Method

Participants

Participants (N = 159) were undergraduate students from a large Midwestern university and were recruited through educational psychology courses on campus. During two separate but similar administrations, students were asked to complete the FID-CS survey prior to beginning work with an chemistry tutoring system. Since the activity for both administrations was the same, we combined the two samples for analysis. Across both administrations, information was collected for each participant about the number of undergraduate chemistry courses taken. For the second administration, additional information about gender and intended major was also collected.

Survey Items

The FID-CS instrument modifies the text of each FID-ES item to reflect the new content area (i.e. chemistry), and to describe interactions with the content in ways more specific to chemistry. For example, the original FID-ES item "I work on engineering projects outside of school at least once a week" was modified to read "I work on chemistry projects or learning chemistry that is not required for class at least once a week". The basic structure of the survey (e.g. 12 items on a 7 point Likert scale) remains unchanged. Table 1 lists all 12 FID-CS items.

[Place Table 1 here]

Results

To analyze the data, we examined the reliability of the survey, provide basic descriptive information, and compared differences in FID-CS interest scale scores by number of chemistry classes taken. For those participants in the second administration (n = 85) we also compared group differences in interest scores for gender, and related major using t-tests. In all comparisons, statistical significance was defined as $\alpha = 0.05$.

We found the survey to be highly reliable ($\alpha = 0.88$), with an overall mean interest scale score well below the middle point of the scale ($M = 2.72$, $\sigma = 1.11$) and a distribution of scores about the mean skewed to the right. An ANOVA test showed differences between mean interest scale scores based on the number of undergraduate chemistry courses taken ($F(1,157) = 54.37$, $p < 0.05$). A post-hoc comparison of means using Bonferroni corrections revealed that FID-CS interest scale scores for those with no undergraduate chemistry courses was lowest ($M = 2.03$, $\sigma = 0.82$), and was significantly lower than those who had taken 1 ($M = 2.63$, $\sigma = 0.96$; $t(88) = 3.20$, $p < 0.05$), 2 courses ($M = 3.12$, $\sigma = 0.87$; $t(85) = 5.87$, $p < 0.05$) and 3 or more courses ($M = 3.46$, $\sigma = 1.22$; $t(88) = 6.65$, $p < 0.05$). We also found that those who had taken 1 undergraduate chemistry course had significantly lower scores than those who took 3 or more courses ($t(70) = 3.18$, $p < 0.05$) See Figure 1 for the overall distribution of interest scale scores, and Figure 2 for a plot comparing scores by number of chemistry courses taken.

For the data from the second administration of ChemTutor, we then conducted a t-test comparison of mean FID-CS scores based on gender and whether the participant indicated a STEM related major. We found a significantly higher FID-CS score for men compared to women ($t(83) = 2.59$, $p < 0.05$), and for those with a STEM related major as compared to a non-STEM major ($t(83) = 5.43$, $p < 0.05$).

[Place Figure 1 here]

Conclusion

In this paper, we endeavored to demonstrate the versatility of the FID-ES survey by evaluating the validity and reliability of the FID-CS, and to suggest the use of variations of the survey as a tool to facilitate tailored instruction to better promote interest development in STEM domains. To address our first goal, this study adds to previous evidence that the FID-ES survey and its variations demonstrate high reliability and are valid measures of learner interest. Estimates of reliability, using measures of Cronbach's alpha, of the FID-CS ($\alpha = 0.88$) are consistent with previous findings of Cronbach's alpha for the FID-ES ($\alpha = 0.89$, 0.84, and 0.81) and a version of the FID-ES modified for reading (0.81). This consistent finding of alphas greater than 0.80 is evidence of the stability of the survey's reliability across adaptations made for age, domain, and context. The validity of the FID-CS was demonstrated through differences between groups that are both consistent with prior work on interest in chemistry (e.g. males have been generally found to have higher interest in chemistry), and with student choices (e.g. those enrolling in an educational psychology course and having taken fewer chemistry courses should have lower interest in chemistry). We therefore conclude that the FID-ES survey can be adapted for various uses without a decline in reliability and or validity. By utilizing this information, more can be done to tailor instruction to meet the specific needs of those at varying levels of interest, as suggested by interest development researchers such as Järvelä and Renninger (2014).

While the FID-ES and FID-CS have demonstrated reliability and validity in all testing thus far, there are a few limitations to this work which reduce the generalizability of these results. First, we feel that the FID-ES survey appears to be robust in modification, but it has only been tested in a few limited cases. Further study of the survey's properties as a measurement tool need to be conducted for new STEM (e.g. physics) and non-STEM (e.g. art) domains, as well as a greater variety of demographics and contexts. Increased use of the survey in a broad number of applications will further deepen our understanding of what survey results should look like. Documenting survey results from a variety of uses will help inform interest level cut-off values (i.e. defining low interest as below a certain FID-ES value prior to a study), and aid in calibrating the survey to measure changes in interest over time. Another limitation is the relatively small sample sizes of some of the studies presented, and those in the two administrations of this study. Future work should attempt to make similar tests of the FID-ES and related surveys on a much larger scale.

This work provides both practical and theoretical implications for future work. In practice, the FID-ES, FID-CS, or other modified versions of the survey can be used as tools to measure interest prior to students beginning work in adaptive learning environments. This can be used to tailor instruction for individual learners as they conduct their work, and evaluate program efficacy through monitoring growth in interest a domain during participation. We also present evidence that lends empirical support to the descriptions of leaners at different phases of interest (Renninger & Su, 2011) by demonstrating the validity of a survey tool used to measure interest based on these characteristics.

In conclusion, we hope that others find the FID-ES and related surveys to be beneficial in their work, and that providing this tool along with results from several administrations can give insight into what to expect in future uses. If we are to truly work towards motivating future generations to pursue STEM related fields, deliberately tailoring instruction to develop learner interest in these fields is crucial. To make this a reality the development of valid, reliable, and flexible measurement tools such as the FID-ES instrument is an important aspect.

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Acknowledgments

Blinded for Review

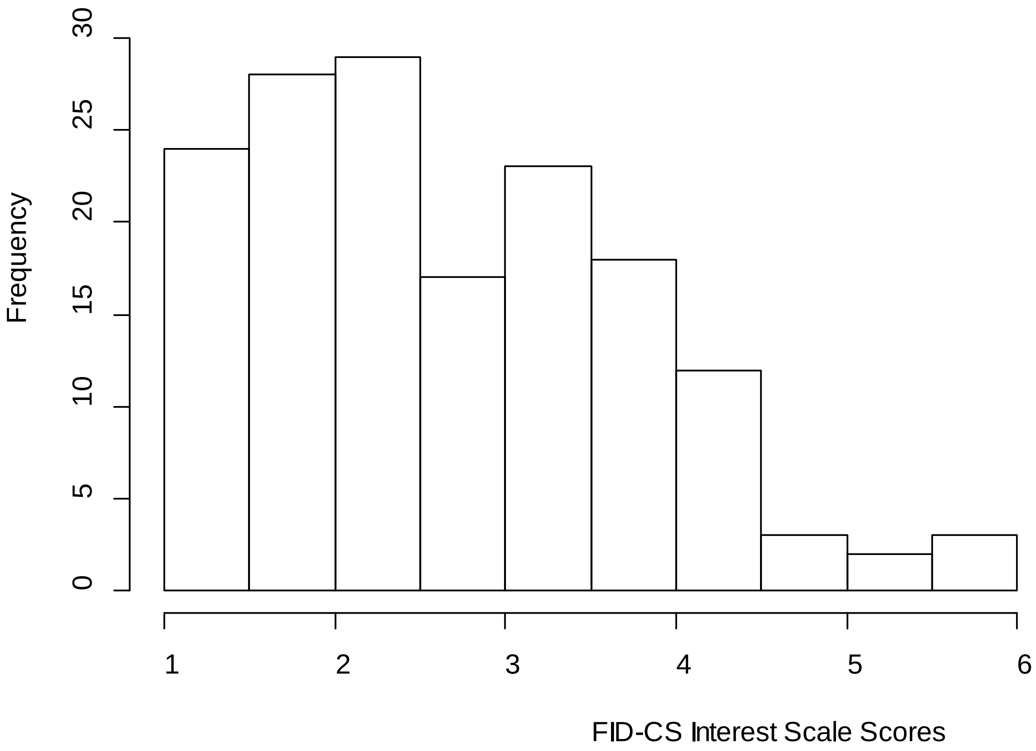

Table 1: FID-CS items.

- I enjoy learning about chemistry even when it is very difficult.
- I know way more about chemistry than other students I know.
- I think about my own questions about chemistry that are not for required for class at least once a week.
- Compared to other students, I am way better at doing chemistry work.
- Knowing about chemistry is extremely valuable to me.
- I work on chemistry projects or learning chemistry that is not required for class at least once a week.
- I know a lot about the chemistry topics that I find interesting.
- I think everyone should know a lot about chemistry
- I'm inspired to learn more about chemistry on my own when I see something in chemistry that interests me.
- I always learn more about chemistry on my own if I find it interesting
- When chemistry interests me, I am confident that I can learn about it extremely easily.
- When I'm working on something in chemistry that I think is interesting, I continue working even when it takes a lot of time.

Figure 1. Distribution of FID-CS

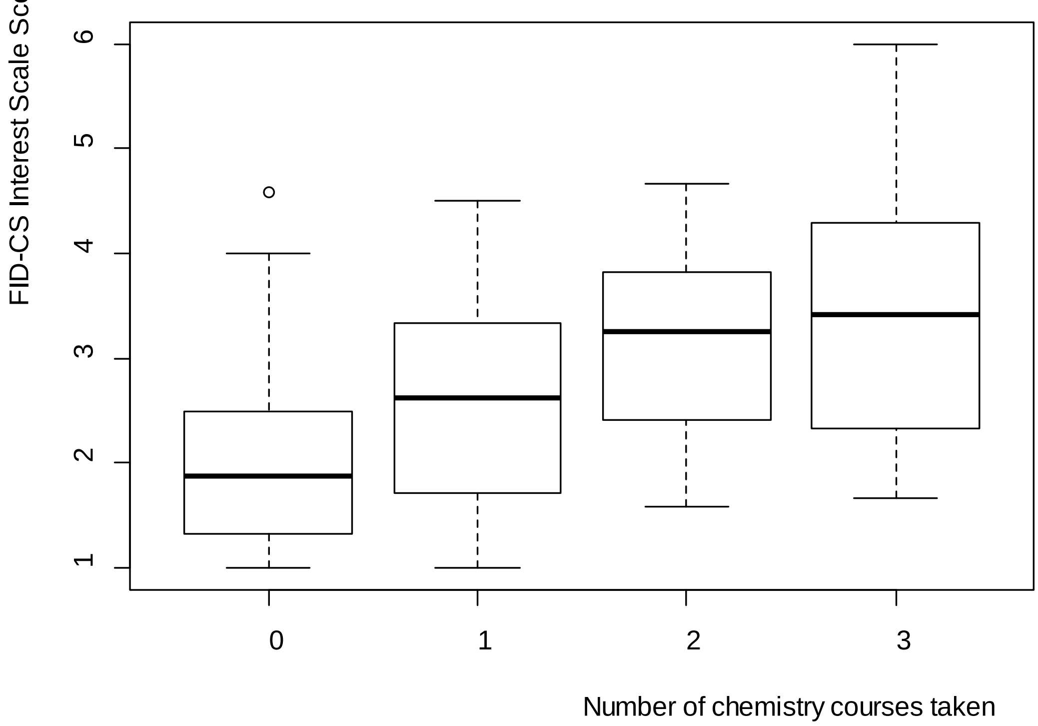

Figure 2. Plot of FID-CS scores by total chemistry courses taken.