Finding classroom tasks interesting: Building towards a lasting desire to re-engage in four foundation courses

Authors:

Luke K. Fryer, The University of Hong Kong, Faculty of Education, CETL

Contact: lukefryer@yahoo.com

Address: The University of Hong Kong, Pokfulam Rd. Hong Kong, SAR

Alex Shum, The University of Hong Kong, Faculty of Science

Evan John Pickett, The University of Hong Kong, Faculty of Science

George Viche Akom, The University of Hong Kong, Faculty of Science

Timothy D. Wotherspoon, The University of Hong Kong, Faculty of Science

FUNDING:

This research was partially funded by a General Research Fund grant from Hong Kong's RGC and a Teaching Development Grant from the University of Hong Kong.

Pre-Printed 14 OCT 2021

Finding classroom tasks interesting: Building towards a lasting desire to re-engage in four foundation courses

ABSTRACT:

The paired development of an individual's knowledge and interest in an object/topic has well-established theoretical and empirical support. Their shared role within learning experiences has similar support but has less often been researched intensively in formal contexts such as classrooms. To address this gap, four studies in four foundation university courses were conducted across an academic semester. The research was conducted at one research intensive university in Hong Kong, with a mixture of first- and second-year students. This research was embedded into course lectures/tutorials by utilising a mobile platform to conduct short formative tests and surveys (QR codes presented with course materials). Difference testing compared pre-post domain interest and levels of interest in different tasks. Structural equation modelling tested the predictive relationships between prior domain interest and knowledge with students' interest in a range of lecture and tutorial tasks, and later interest in the course and/or domain. The pattern of results from the four studies suggest separate and sometimes contrasting roles for prior interest and knowledge within task interest. Findings confirmed the critical role of social learning experiences for building interest in courses. These studies support the evidenced based strategic choice of a variety of course tasks to ensure students individual differences are addressed and long-term interest is supported. The theoretical and practical implications, as well as future directions for research in this area are discussed.

Educators are often at the mercy of students' individual differences (c.f., Jonassen & Grabowski, 2012). Students can come to a new class/course wanting to learn as much as they possibly can, ready to build on their burgeoning domain interest. Students can also come to the classroom completely ambivalent or worse yet, dreading the hours of learning to come. Compounding this issue, students often come to new learning situations with disparate levels of prior knowledge (Kopcha & Sullivan, 2008). The impact of individual differences can be particularly strong in the structured context of classroom learning because all students are expected to engage with the same materials in a consistent manner regardless of prior knowledge or motivation.

Many educators are sensitive to the individual differences that impact students' engagement and longer-term desire to re-engage with learning materials (i.e., interest in an object; Renninger & Hidi, 2015; Renninger & Su, 2019). There are at least two reasons why this sensitivity, while laudable, might not be sufficient to substantively address students' individual differences. First, educators often face substantial heterogeneity that classroom (30+ students) or tutorial/lecture numbers (15+/100+ students) naturally generate. Second, like many educating instincts, a clear understanding of students' prior interest and knowledge might not be susceptible to insights yielded by educators' "gut feelings". A good example of this is educators' overconfidence in educational technology as a meaningful source of engagement (Fryer et al., 2017).

The current research set out to establish the type of measurement and modelling necessary to test and, critically, retest the connections between the prior knowledge and domain interest students bring with them to new learning environments like university courses (i.e., readiness for learning; Renninger & Hidi, 2020) to and through the often constrained learning experiences they offer (i.e., lecture/tutorial tasks). Understanding the combined role of these factors within students' eventual course and/or domain interest is critical, as it connects courses and years of study.

Results from four studies included in the current research point to the very different, sometimes overlapping, and occasionally not significant roles for prior knowledge and domain interest within future learning experiences and broader interest development. The pattern of results from these studies are drawn upon for theoretical and practical direction regarding how these critical individual differences might be addressed by educators aiming to maximise students' interest in their course and the broader domain of study.

1 Background

1.1 The critical role of prior individual differences for learning

Students' individual differences are well-established, large sources of variance for learning outcomes. Meta-analyses of education broadly (Hattie, 2009) and within higher education specifically (Richardson et al., 2012; Schneider & Preckel, 2017) present an overwhelming case for the ubiquitous and strong effect of individual differences, but fail, due to their nature, to make connections to and through students' learning experiences. For most reviews and meta-analyses in this area, individual differences are generally assessed by the strength of their correlation with achievement outcomes. In the life-long-run, however, it is reasonable to expect that learning outcomes like a desire to re-engage with learning materials (i.e., interest) is just as important as a course outcome. This argument is especially strong for foundation courses seeking to broaden students' horizons and help them find connections between close and distant fields (i.e., to their chosen major). Many universities have a general education programme made up of such foundation courses, but their impact on students is rarely assessed.

1.2 The role of prior knowledge

For many educational researchers, prior knowledge (i.e., in the current study, the amount of knowledge an individual has about a course's content before engaging in the course) is primarily something to be controlled for. However, due its complex role with learning experiences and its outsized effect on outcomes (Ausubel et al., 1968; Tobias, 1994), this narrow perspective can be a mistake. It is well accepted that prior knowledge can account for between 30-60% of the variance of future learning (Tobias, 1994). For decades, researchers have stated that prior knowledge is without a doubt the single most important variable when modelling learning (i.e., at least as far back as the 60s; e.g., Ausubel et al., 1968). Learning in most cases is a constant process of building on prior knowledge, integrating new ideas into prior knowledge (Dochy, 1992), and adjusting prior knowledge to fit new experiences/concepts (Hewson & Hewson, 1983; Vosniadou, 1992). In many cases the more prior knowledge (and the greater its depth) the deeper new learning experiences can be (Alexander, 2003).

Prior knowledge is also tied to critical latent constructs, such as beliefs about domain-specific ability, retrospectively (self-concept; Marsh et al., 2016) and prospectively (self-efficacy; Bandura, 1997); both of which have established links to learning outcomes even after controlling for prior knowledge (Bandura, 1993; Marsh & Craven, 2006). Somewhat

less obvious, but consistent with current theory, prior knowledge is strongly tied to interest and its development across different types of learner-object engagements (Durik & Matarazzo, 2009; Hidi & Renninger, 2006; Renninger & Hidi, 2011; Renninger et al., 1992; Schiefele, 1992).

A substantial body of empirical research has connected students' interest in and knowledge of a domain. Building on robust meta-analyses relationships between prior knowledge and interest ($r=.30$; Schiefele et al., 1993), Marsh et al. (2005) presented evidence suggesting reciprocal links over time (year 7 students). Longitudinal, correlational research (K-12) suggested strong connections between interest and ability beliefs, but weaker relations connecting interest and actual knowledge (Denissen et al., 2017). Longitudinal research in the context of mathematics with year 8 students in China (Xu, 2018) and year 6-9 students in Australia (Griggs et al., 2018) indicated no significant predictive connection in either direction and a single small connection from interest to a future knowledge assessment respectively. Subsequent longitudinal modelling in the context of foreign language learning (university students), however, supported robust reciprocal connections between interest and knowledge (Fryer & Ainley, 2019).

1.3 Interest and its development

Interest's ties to prior knowledge are seeded in interest's most basic definition as a relationship between an individual and an object (Hidi & Renninger, 2006). This relationship relies on the individual knowing something about the object and the growth of this relationship is in large part based on a growing understanding of the object (Hidi & Renninger, 2006). Perhaps the most meaningful (for an educator), short definition of interest is that it is a desire to re-engage with an object, a desire to learn more about the object (see Renninger & Hidi, 2015).

Interest is generally divided into at least two stages (Hidi et al., 2004): a) Situational interest, which describes an interest which is largely affective and often stimulated by, and reliant on the environment, b) Individual interest, which describes an interest which is more developed and is a multi-dimensional construct still made up of some emotional components but also varying amounts of value and epistemological elements. At least within educational contexts, the most common model for discussing how individuals might develop their interest across a series of re-engagements with an object is the Four Phase Model (Hidi & Renninger, 2006; Renninger & Hidi, 2011, 2015). The Four Phase Model describes the potential development of an individual's interest from triggered situational interest (i.e., a primarily

affective experience arising from and reliant on the environment), to maintained situational (i.e., still largely affective, but diversifying and with a weakening reliance on the environment), to emerging individual (i.e., initial stages of a multi-dimensional interest construct which includes affective elements, with growing epistemological and value components, together becoming a resource which drives re-engagement), and finally well-developed individual interest which is a natural potential extension of emerging individual interest experiences. This final phase of interest development can be an enduring source of motivation to reengage with its object, potentially resulting in continued knowledge and interest growth.

The Four Phase Model (Hidi & Renninger, 2006; Renninger & Hidi, 2011) has implications for the role of prior knowledge and interest within future interest: it suggests that increasing amounts of both will yield a deeper interest in an object. Empirical examinations of the connections between personal interest and future engagements with the domain are relatively rare, with the majority of research being either cross-sectional or connecting past to future personal interest (see recent examples such as Fryer & Ainley, 2019; Griggs et al, 2018; Xu, 2018).

Rotgans and Schmidt (2018) is a rare example of research directly addressing the longitudinal role of initial personal interest within future situational interest during classroom learning. Their research was undertaken across three learning sessions, from two studies with primary and secondary school samples. Their results supported the important role of prior individual interest within students' situational interest. Their findings also pointed to substantial variance in the strength of prior individual interest' contribution to future situational interest. This variance can be attributed in large part to the nature of the tasks (type of instruction) students were engaged in. Renninger et al.'s (2019) qualitative study partially echoes this sentiment, pointing to the paired role of the nature of a particular activity and readiness of the learner within the development of interest (Renninger & Hidi, 2020).

1.4 Measuring and modelling interest development in university classrooms

The Four Phase Model is a detailed composite of decades of careful research regarding the development of interest. It is a useful description of the natural process of interest development and is a firm foundation for understanding how different types of engagement with an object might lead to the development of interest in the object. Across the process of formal education, however, a refocusing of the phases to better understand the objects and types of learning experiences might benefit teachers and students alike. To begin

with, formal education can constrain the natural process described by the Four Phase Model: students often have scant choice about what, how much, where, with whom, and how quickly they need to learn. Students and their educators learn and teach within specific subjects or courses with a set number of engagements (i.e., classes, tutorials, labs, excursions, etc). Educators necessarily break their engagements into a series of tasks, which are often repeated monthly, weekly and/or daily. It is natural for educators to want to know which and what kinds of tasks are effective for getting students interested in their subjects (K-12) and courses (tertiary). Educators are less likely to be curious about the specific phase of students' interest.

A refocus in the phases of interest to match these contexts suggests three practical objects of student interest that can encapsulate the four phases of interest across a university course. a) Domain interest is the interest students come to a university course with and grows or diminishes across the course experience. Domain interest is consistent with individual interest, not differentiating between emerging and well-developed. b) Course interest is students' interest in the course: the course of study is the object of interest. The course is set a series of experiences, with a curriculum, teacher/s and a group of peers. Course interest is a mixture of interest in this environment and the myriad series of tasks students engage in. c) Task interest explicitly and solely represents the interest students experience while engaging in each of the full range of tasks a course offers both in and outside of class. Task interest is consistent with situational interest, not differentiating between triggered/maintained and with a specific task as the object (Fryer et al., 2016). Focus on the role and function of students' interest in specific tasks has proven a successful means of advancing our understanding of student learning (e.g., with primary school students; Nuutila et al., 2018)

Initial research (Fryer et al., 2016) tested a longitudinal model at three levels of specificity (objects) of interest (i.e., sequentially: domain, task, task, task, course, and domain interest) across a semester-long course. This research and subsequent extensions/replications (Fryer et al., 2017, 2019a, 2020a, 2020b, 2021) have yielded some recurring linkages, each presenting theoretical and practical implications for teaching and learning in specific environments and for specific types of tasks. The first finding is the important role of prior domain interest within students' interest in future tasks and domain interest (Fryer et al., 2016). The second finding is the mediating role of course interest between prior task interest and future domain interest (Fryer et al., 2016, 2020a). The third finding is that neither observed engagement (by teachers) and nor the quantity of self-reported task interest (students) are useful indicators of different tasks' (interest) contribution to future course interest (Fryer et al., 2017, 2019a). Building on these findings, Renninger and Hidi (2020)

contented that both type of the task and student's readiness (e.g., prior interest and knowledge) have a critical impact on student experiences and their eventual desire to reengage (i.e., interest), which demands further investigation to verify and then better explain the impact of students' readiness on task experiences.

1.4.1 The impact of social experiences on interest

Considerable research supports the inclusion of elements of peer learning in university classrooms (Bell & Lygo-Baker, 2019; Topping, 2005). There is a strong base of evidence to confirm the role of social and public engagement as a means of enhancing interest development at school (Bergin, 2016). A wide variety of such experiences have an established impact on students' interest. Both subtle (e.g., vicarious experiences; Bergin 1999) and explicit (public demonstration, Bergin et al., 2013) social experiences are important. Like most of our knowledge about such quantitative connections, however, the moderating role of students' initial individual differences (e.g., readiness; Renninger & Hidi, 2020) is not well understood. Most instructors would agree that including some socially orientated tasks is important, but what kind? How many students? Should the focus be on encouraging vicarious experiences or providing opportunities for public demonstration of student knowledge? These kinds of questions can only be answered through repeated task level investigations with a wide variety of students, course environments and curricula.

1.4.2 Foundation courses and their role in stimulating student interest

Building on a pilot study, the current study was undertaken in first and second-year transdisciplinary, foundation university courses. Seeking to broaden students' knowledge and interests is a common aim for foundation courses at university. Students in different faculties come to these courses with a broad range of prior knowledge and domain interests. Some students may merely seek compulsory credits or be opting for the easiest course they can find. Other students might follow past interests, and some might simply follow their friends' lead when choosing a course. Finally, some students might be seeking something totally new, a fresh challenge, or maybe even some inspiration when selecting their courses. These types of courses are therefore prime contexts for research for two important reasons. First, the variance in students' knowledge and motivation in such courses is high, a critical factor for quantitative research. Second, because the courses are actively seeking to stimulate and sustain interest in new domains, these courses are in a strong position to put any potential findings into practice quickly.

1.5 Current study

The current project, consisted of four studies in four transdisciplinary, university foundation courses (each described in the methods section). This study was designed to examine the potential impact of different (regularly used) course tasks in the fostering of students' interest in the course and/or the broader domain. All four studies were specifically designed to assess the interaction between students' prior course-relevant knowledge and interest (i.e., readiness; Renninger & Hidi, 2020) and their resulting interest in a variety of course tasks they commonly faced. Subsequently, the longitudinal effect of these constructs (prior interest, prior knowledge and task interest) on students' future interest in the course and/or domain was also assessed to determine the longer-term implications of these interactions.

2 Aims

The present research aimed to address three research questions (RQ) in four studies undertaken across one academic year in four separate university courses. 1) What are the differential effects of prior knowledge and prior domain interest on students' interest in an array of different tasks in a single course, and is there a pattern of relationships with similar types of tasks over the different courses (RQ1)? 2) How are interest in different course tasks interlinked longitudinally? 3) What is the longitudinal role of prior interest, prior knowledge and task interest within future interest in a course or domain (RQ3)?

Based on the available research specifically examining the predictive relationship from prior knowledge and prior interest to future task, course and domain interest, two preliminary hypotheses were tested. a) Prior knowledge and interest (i.e., components of students' readiness) were hypothesised to differentially impact students' interest in tasks: i.e., students who were more interested in the domain would find different tasks interesting compared to students who had more prior knowledge of course material (Hypothesis1). b) Of the tasks modelled in the four studies, there is sufficient past research to support a strong role for tasks with a social component having a strong predictive connection to interest development: i.e., higher post course or domain interest, after accounting for prior interest (Hypothesis2).

3 Methods

3.1 *Participants*

First and second-year students from 10 faculties at one research intensive university in Hong Kong participated in the four studies presented. A complete faculty breakdown of the sample for each study (1. $n=54$, Female=26; 2. $n=63$, Female=46 3. $n=72$, Female=23 4. $n=100$, Female=33) is included in Appendices (Table 1). The four studies were undertaken with intact classes of students engaging in a university foundation course. Course lecturers were recruited as part of a university initiative to better understand student engagement during lectures and tutorials.

3.2 *Measures*

Three measures of interest at the task, course and domain level were employed in the current research. The Task interest scale was three items in length and drew on items from past task interest-orientated research (Fryer et al., 2016, 2017, 2019a, 2020a, 2021): This task was interesting; I want to learn by doing tasks like this; This task was personally meaningful. The Course interest scale was also drawn from the same past research and also consisted of three items: This course is interesting; This course is personally meaningful; I want to learn more in courses like this. Both the Task and Course interest scales utilised a six-point response scale from Nothing Like Me - Exactly Like Me.

The domain interest measure used a recent personal interest scale (Renninger & Schofield, 2014). This scale includes items asking specifically about students' behaviour engaging with the domain along with their confidence in their knowledge of the domain of study. Five items were in the scales: 1) How much do you know about ____?; 2) In your spare time, how often have you tried to learn about ____?; 3) I have spent time learning about _____ on my own.; 4) I'm confident in my knowledge of _____; 5) I always have questions about _____. Items 3 & 5 were preceded by "How well does this statement match you?" and were answered across a six-point cumulative self-report (Almost Never - Almost Always). All Items were measured across a six-point cumulative response scale: For Item #1 Almost Nothing - Almost Everything; for items #2, 3, 5 Almost never- Almost everything; for item #4 Not at all - Totally. The tests of prior knowledge were developed by the course instructors who were best situated to determine what constituted prior knowledge of the subsequent course contents. To maintain consistency across studies, the prior knowledge assessments were all multiple choice and took no more than 15 minutes to complete.

3.3 Courses contexts

The studies evaluated four separate courses offered as part of a scientific literacy initiative within the university's general education foundation program. All undergraduate students are required to take at least one scientific literacy course as part of their foundation course experience. Prior knowledge and prior domain interest were assessed at the beginning of each course (T1 in all studies) except for Study 2 where only domain interest was measured at T1. Initially enrolled students and average attendance for course tutorials for each course is presented in the appendices (Table 6). The prior knowledge tests for each study, with their distribution of achievement is presented in the supplemental data section.

Responses for Study 1 ($n=57$) were provided by students from a course that critically analysed the reporting of *science in mass media*. A broad course aim was to support students' ability in discerning between scientific and pseudoscientific claims. Students identified and then discussed the scientific reputability of techniques used in advertisements to market products (T2). Students used pseudoscientific techniques to market a false product, and then explained the true (or lack of) science behind their claims (T3). Course interest (T4) and post domain interest (T5) were evaluated towards the end of the course.

Study 2 ($n=54$) analysed a course on *scientific revolutions* and their impacts on modern societies. Students were assessed on their prior knowledge and engaged in activities that fostered understanding of the scientific method. Students were assessed on the use of inductive and deductive reasoning (Prior Knowledge; T2a). In the same class, students collaboratively determined the steps involved in helping two students untie themselves, and then categorised the ideas into the steps of the scientific method (T2b). In a later class, another activity illustrated the nonlinearity of scientific progress, where students completed a puzzle, which required a substantially different solution when complexity was added (T3). Course interest was measured towards the end of the term (T4). Course assessments included a group presentation, essay, reading assessments and in-class test.

Study 3 ($n=74$) investigated a course on the use of *statistics for understanding social and economic issues*. Teachers employed a mix of lectures, worksheets, discussions and practical skill development. For this study, three tasks: a lecture and discussion on elections and polling (T2), a small group exercise and discussion on the quality of Likert scales (T3) and a worksheet on the consequences of regression to the mean (T4) were evaluated. Students were evaluated on three written assignments (one of which is a group project), a final exam, and tutorial participation.

Study 4 (n=100) investigated a course on *physics* (Mechanics, Electricity and Magnetism). Development of calculation skills was limited, instead placing a focus on theoretical concepts and using language to express understanding. The course is open to all students, however mainly engineering and science students enroll. Students often arrive to the course having learned related calculation skills in secondary school, though are weaker in theoretical understanding. The prior knowledge measure tested students' proficiency with projectile motion and Newton's Three Laws. The included activities in part reflect the cumulative nature of knowledge in physics education. In the first class, students were asked to answer a written question, followed by paired discussion regarding freefall, i.e. heavier objects with similar shape/size fall faster at terminal velocity (T1). The paired discussion regarding circular motion, which was facilitating using a multiple-choice prompt (T2) is a precursor to a short lecture on forces involved in circular motion (T3; centripetal forces). Students were asked to draw and label a diagram to explain centripetal forces provided by friction on wheels, followed by an explanation that challenged pre-existing conceptions learned in secondary school (T4). A writing exercise regarding linear momentum served as a sample quiz question (T5). Finally, a writing exercise on a far-removed topic not learned in secondary school: semi-conductors was included (T6). Domain interest was measured once more near the end of the course (T7). Assessments included a presentation, an essay on a topic related to the presentation, two quizzes testing theoretical concepts and tutorial participation. The activities included in the study all supported preparation for the quizzes.

3.4 Procedures

For each study, the researchers worked with course instructors to integrate the project's interest assessment into weekly tutorials or lectures. All surveys and tests were conducted on a bespoke mobile platform, through students' mobile phones or tablets (Fryer et al., 2019b; 2020c). Surveys and tests were created online, QR codes for the online location were exported and then inserted into lecture or tutorial materials (usually powerpoints). Instructors selected a variety of tasks that were commonly undertaken, but different in nature between the respective courses.

Students first use of the online survey system began with the creation of a unique, anonymous login. Students were then instructed to read an overview of the projects' aims and procedures. Finally, students read the ethics statement for the study, stipulating that participation was voluntary and that they could withdraw anytime even if consent was previously given. The university's ethics committee reviewed the current research and

granted permission to conduct these studies as part of a larger, five-year project assessing students' experiences at university.

All four studies were conducted across one academic semester of fifteen weeks. For each study, prior Domain interest and prior knowledge, along with between two and four Task interest measures, and Course/Domain interest as an outcome were included. Only students completing both the pre and post (outcome) measures were included in the study to ensure compliance with students' consent to participate in the study. The sequence of research design for each study is presented in the Appendices (Figure 1-4).

3.5 Analyses

Prior to analysis, missing data (between 6 and 9% for each of the four studies) was imputed using JMP 14.2.0 (SAS, 2020) REML algorithm. Analyses for the four studies presented included a mix of difference testing: ANOVAs for levels of Task interest (Studies 1-4) and a *t*-test for pre/post domain interest (Study 4). This difference testing determined whether students reported significantly different amounts of interest for the tasks assessed (Studies 1-4). These tests ascertained whether students' domain interest was significantly changing across the course (Studies 2 and 3). Partial Least Squares Latent Structural Equation Modelling (PLS-SEM) tested a) predictive relationships between prior interest and knowledge with future task interest (RQ1 and H1-2), b) the interconnected nature of students' task interest experiences (RQ2), c) the nature of the contribution of prior Domain interest and knowledge, as well as task interest, for future Course and Domain interest (RQ3 and H2). To these ends, Study 1 was undertaken first as pilot, pursuing a simplified modelling approach with Course interest as the only dependent variable. For Studies 2-4, a fully-forward modelling approach was taken (i.e., all prior variables predicting all future variables) to control for and capture the interconnected nature of the data collected.

Consistent with recent small-scale modelling in educational research (e.g., Lombardi et al., 2018; Torsney et al., 2019), variance-based latent Partial Least Squares Structural Equation Modelling (PLS-SEM) was utilised in the current study. There are a few reasons why variance-based SEM modelling is preferred over covariance SEM. PLS latent modelling (similar to covariance-based latent SEM) offers the benefits of latent variables and full model tests not possible with standard multiple regression approaches. Furthermore, latent PLS is robust to non-normality issues (Hair et al., 2016), which are often linked to ordinal Likert-type data (Flora & Curran, 2004). Furthermore, for smaller samples, where convergence

issues are independent of complexity of the tested model, the PLS approach to latent modelling can be of significant benefit (Jannoo et al., 2014).

SmartPLS software package was used for all Structural Equation Modelling (Ringle et al., 2019) in the current study. As part of model tests, validity and reliability of the latent constructs was assessed (based on guidelines from Hair, et al., 2019). As part of this process, Variance Inflation Factor (VIF) for composite variable items and composite variables collinearity was verified. Consistent with PLS-SEM analysis guidelines (Hair, et al., 2019), VIF of 3 or less is preferred with > 5 indicting critical collinearity. Average Variance Explained (AVE; a measure of convergent validity) was similarly calculated and reviewed, with values of .50 or greater being preferred. Factor loadings for each composite variable were examined, with loadings of .50 or greater being preferred. At a final stage, composite variable's reliabilities were tested, employing Cronbach's Alpha and Rho(a). For each reliability measure .70-.90 preferred, $< .70$ suggesting poor reliability and $> .95$ indicating redundancy for indicators.

Consistent with Hair et al.'s (2019) recommendations, we assessed whether the sample size was sufficient to confidently test each of the models included in the four studies, a regression power analysis was conducted for each dependent composite variable. Power analyses were conducted using G*power (Faul, Erdfelder, Lang, & Buchner, 2007).

4 Results

Variance Inflation Factor, Average Variance Explained and Item loading for all latent constructs examined across the four studies and were acceptable based on recent guidelines for PLS-SEM (Hair et al., 2019). Reliability for each of the latent constructs (presented in Tables 2-5, Appendix) in each model were also well above established acceptable heuristics ($> .70$; Devellis, 2012). Pairwise correlations, descriptive statistics and reliabilities for each of the studies are presented in the appendices (Appendix Tables 1-4). Due to a lack of space and a focus on the results of the longitudinal models, these results will not be reviewed. Modelling for each study (Figure 5-8) is presented from left to right, from prior interest and prior knowledge to Task interest and onto interest outcomes (Course and/or Domain). Only significant ($p < .05$) β s are presented. For complete regression results please see Tables 6-9 (Appendices).

4.1 Study 1 (Figure 5)

t-test of the two tasks indicated no significant difference in students' interest ($t(55)=.17, p=.86; d=.02$). Due to the use of Domain interest as a prior measure and course interest as a post measure, a pre-post interest difference test was not possible.

Prior knowledge was a non-significant predictor, but prior Domain interest ($\beta=.29$) was a large predictor for future Course interest (RQ-1, RQ-2). Only students' interest in the group presentation task significantly predicted ($p<.05$) course interest (RQ-3; $\beta=.50$). Modelling resulted in a substantial amount of variance being explained for the post Course interest ($R^2=.58$).

4.2 Study 2 (Figure 6)

ANOVA for the T1 Modelling Activity (What is science?), T2 Game group problem and T3 Modelling Activity (Kuhn's model) indicated no significant differences ($F(2,3)=.42, p<.05; R^2=.01$). Tukey HSD post-hoc test of pairwise differences indicated no significant differences ($p<.05$).

Prior knowledge (T1) predicted ($p<.05$) task interest for (T2 Game group problem ; $\beta=.32$), but failed to significantly predict the T3 modelling activity (RQ-3). Contrasting with prior knowledge, students' prior domain interest (T1) significantly predicted ($p<.05$) task interest for the T1 modelling activity (RQ-2, $\beta=.25$), but failed to significantly predict the game group problem. The interest in the modelling task at T1 significantly predicted both the T2 Game Group Problem ($\beta=.36$) and the T3 modelling activity ($\beta=.25$).

4.3 Study 3 (Figure 7)

ANOVA of the four tasks indicated no statistically significant difference between students' interest in these experiences ($F(3,4)=.197, p<.05; R^2=.02$). Post-hoc HSD test confirmed no pairwise differences.

Neither prior knowledge nor prior interest significantly predicted interest in any future tasks (T2-4) nor future course interest (T5) (RQ-1, RQ-2). Task interest for the Lecture-Discussion on elections/polling (T1) however, significantly predicted Task interest for the short lecture on graphs (T2, $\beta=.50$) and worksheets on regression (T3, $\beta=.33$). The only significant β for Course interest (T5) was Task interest for the regression worksheets ($\beta=.30$). Modelling resulted in a substantial amount of variance being explained for post domain interest ($R^2=.33$, RQ-3).

4.4 Study 4 (Figure 8)

A t -test indicated no significant difference between pre and post Domain interest across study four ($t(99)=-1.196, p=.235; d=-.12$). An ANOVA test of the difference between the six tasks indicated significant differences in task interest ($F(4,5)=7.154, p<.0001; R^2=.06$). Pairwise Tukey-Kramer HSD found moderate significant difference between the higher Task interest for T4 (Paired discussion - Wheel) and T6 (Writing exercise - semiconductor) tasks than the T3 (Short lecture - centripetal force) and T5 (writing exercise - linear momentum) tasks: T4 and T3 ($t(99)=8.11, p=.001; d=.81$); T4 and T5 ($t(99)=7.85, p=.001; d=.78$); T6 and T3 ($t(99)=5.89, p=.001; d=.59$); T6 and T5 ($t(99)=8.29, p=.001; d=.83$).

The only significant β from students' initial readiness was from T1 prior domain interest to T7 post domain interest (RQ3). T1 Task interest (paired discussion, freefall) presented large β s for both proximal T2 ($\beta=.52$; paired discussion circular motion) and T3 ($\beta=.27$; short lecture centripetal force), T5 Task interest ($\beta=.35$, writing exercise, linear momentum). Likewise, T2 Task interest (paired discussion circular motion) presented large β s T3 ($\beta=.54$; short lecture centripetal force) and T4 ($\beta=.32$; paired discussion, wheel). T3 Task interest (short lecture centripetal force) presented a large prediction on T4 ($\beta=.29$; paired discussion, wheel). T4 Task interest (paired discussion, wheel), the final task with a social component, presented the only significant forward link to T7 post Domain interest ($\beta=.30$), but no significant β for the remaining two tasks. T5 Task interest (writing exercise, linear momentum) presented a single significant link ($\beta=.36$) for T6 Task interest (writing exercise, semiconductor).

5 Discussion

Four studies were undertaken in four university foundation courses. These studies tested the predictive role of prior domain interest and prior knowledge within and through students' future task interest, to students' course interest and domain interest. The studies together aimed to address three research questions and test two hypotheses.

With regard to RQ1, there was no clear pattern of evidence regarding the role of prior knowledge within students' future interest. For three of the four models with a post interest (course or domain) outcome, prior Domain interest was a significant and substantial predictor (studies 1, 2, & 4; RQ3). In Study 2 there was clear differential predictive link between the two types of readiness with prior knowledge predicting a group problem-based activity and prior interest predicting a solitary modelling activity (H1).

Addressing RQ2, strong predictive links were observed between most proximal tasks for Studies 2, 3, & 4, suggesting that interest tends to build across course experiences. In study four, consistent with H2, compared to solo tasks (writing and lecture tasks), tasks with a social component (paired discussion) were strong forward predictors of future task interest. Furthermore, the only task to predict future domain interest while controlling for readiness in study 4 was task interest in the final paired discussion. Study 1 also lent support for H1 and Bergin's contention (2013) that public demonstration of competence is an important part of interest development in classrooms (student presentation predicting course interest; $\beta=.50$).

5.1 *Implications for Theory*

The implications for theory from this research arise from patterns of observations across the four studies included in this research. At least four points of theoretical support and/or direction are worthy of note. The first is that prior knowledge was not a robust predictor of either Task interest or interest as an outcome (Course and Domain). Furthermore, in three of the studies presented, the relationship between prior knowledge and domain interest was very small (i.e., $r = .04, -.02, .05, .26$). While this evidence does not necessarily contradict Tobias' (1994) well-cited contention (supported by later theorising: e.g., Alexander, 2003; Hidi & Renninger, 2006) that knowledge and interest develop together, it does suggest that in some contexts, prior knowledge is neither a prerequisite nor (apparently) much direct assistance to getting students interested. Its singular significant prediction was for a Task interest wherein students had an opportunity to demonstrate their knowledge to their peers (Study 2, T2 game group problem). In tandem with Bergin's (2013) findings, that public demonstrations of competence are key experiences for interest development, the role of prior knowledge is an open question, clearly important in Study 2.

Paralleling the weak overall role of prior knowledge, prior Domain interest was also mostly a weak, non-significant predictor of task interest. In contrast, prior Domain interest was an important predictor of interest as an outcome in Studies 2 and 4, suggesting it certainly plays a role in interest development, but might not be necessary for Task interest in foundation courses like those studied here.

Across the four studies, strong interconnections between the Task interest experiences were common. This was especially strong amongst proximal tasks and from tasks with a meaningful social component. Bergin's (2015) contention that peer interactions are key to interest development in classrooms seems as relevant in university contexts as the formal school contexts wherein much of his research is based.

ANOVAs of Task interest across the four studies presented either non-significant (Studies 1, 2, & 3) or significant but very small (Study 4) differences between the amount of interest students reported experiencing in course tasks. The predictive relationships are inconsistent with the quantitative differences. An example of this is that T4 and T6 from Study 4 are not significantly different but only T4 significantly predicts T7 post Domain interest. This is a finding that resonates with past research at the Task interest level (e.g., Fryer et al., 2017). It confirms that it is not the amount of interest that drives interest development, but the nature of the experience, in this case, theory and past research suggest it might be the social nature of the task that matters.

5.2 *Implications for Practice*

The results from this research indicates a few potential directions for enhancing practice. These suggestions are likely to be of direct assistance to educators in the types of courses researched here but might also be potentially relevant to educators in the broader context of higher education, and secondary school educators. The present research indicates that of the tasks here, socially-orientated task experiences comparatively made the predominant contribution to students' interest in their course or the domain of study. This evidence adds to the already substantial body of research supporting the essential role of socially-orientated learning experiences (Bergin, 2016; Boud et al., 2014; Panadero & Järvelä, 2015) for interest as well as other critical outcomes.

The present research, and the research it builds on, suggests that every class should include at least one social task to ensure a steady increase in students' interest in the course. At the same time, educators need to consider the full spectrum of students in their classes. Findings from the current study indicate that if educators want to support engagement and (more importantly) encourage a desire to reengage (i.e., interest) in students with a stronger prior knowledge, they need to include tasks that give these students a chance to flex (test/demonstrate) their academic muscles. Variety is an important part of an interesting course, but strategic (evidence-based) variety is likely to result in the best possible learning environment for heterogeneous student populations (i.e., they are always heterogeneous) (see a similar call from Ainley et al., 2002).

One practical point that arises from the pattern of findings across the four studies is the relatively low impact of prior knowledge on Task, Course and Domain interest. This is in line with the objective of foundation courses like those in the current study. The more accessible such courses are, the more likely students new to the domain are to engage with

them meaningfully. That said, it is still important that as the courses progress that they provide students with opportunities to demonstrate what they have learnt (Bergin, 2013 and leverage that experience to further their interest through demonstration (e.g., Study 2).

A final word of warning is relevant, based both on the present studies and previous research applying the same Task, Course, Domain interest organisation. Neither quantity of behavioural engagement (Fryer et al., 2017) nor self-reported interest (Study four) are a good predictor of future Course or Domain interest growth. The type of engagement is more critical than the amount. Since the right kind of engagement might not always be intuitive and simply self-report from students is not always indicative, there is a need for more studies of the type undertaken here. It is only through longitudinal on-task measurement and predictive modelling that the tasks that drive interest development in courses can be appropriately identified.

6 Limitations and Future directions

As with all research, external validity is the perennial question. The specific context of university foundation courses and the fact that this research was undertaken at one research intensive university must be kept in mind when interpreting our results. This contextual reality should, however, be balanced by the fact that four studies were undertaken. These studies were in four very different courses, with different instructors and students. The majority of the findings presented here relied on a pattern of findings across multiple courses, providing some support for the replicability of the findings and potential external validity.

Future studies in a broader array of courses, at both tertiary and secondary levels of education are called for to test the results from these studies and further discuss the implications raised. Future studies should employ the same longitudinal approach, include robust pre-post measures, assess task experience immediately following their completion, and undertake latent modelling of the resulting data. Future studies that include post measures of achievement will extend the present research as well as provide much needed replication in new contexts. Future studies should also consider how prior knowledge contributes to future interest. Self-efficacy (Bandura, 1993) or performance (achievement) orientated goals (Ames, 1992; Midgley et al., 2001) are two proximal, potential mediators, but a wider net might be cast.

7 Conclusions

Four studies aimed to explicate the relationship between what students bring to courses (knowledge and interest), their task experiences and critical outcomes such as interest in the course and the broader domain. The aim was that replication across courses would present a pattern of useful findings for educators facing the enduring questions "how do I get my students interested?" and "how can I ensure that interest lasts?"

The take-aways from these studies are first that getting students interested in a course is a worthy, if not critical aim that needs to be supported across a curriculum and task-by-task. Second, prior knowledge and prior interest have very different, even contrasting effects on students' interest in classroom tasks. The challenge is devising tasks that appeal to both. What is missing here is how educators support the interest of those students who arrive with neither interest nor knowledge to support their engagement. For these students, targeted interventions aimed at stimulating value (e.g., Harackiewicz & Priniski, 2017; Harackiewicz et al., 2016; Hulleman et al., 2010; Hulleman & Harackiewicz, 2009) and/or self-efficacy (For an example and some potential direction see; Butz et al., 2018; Grigg et al., 2018) might be considered. At least to start, sparking a bit of curiosity (Ainley, 2019), or even just a bit of fun might be that critical emotive trigger (Renninger et al., 2018) that gets the fire started.

Rather than seeing students' diverse individual differences as a roadblock, educators need to see it as a great excuse to constantly test new ideas, to try and reach as many students as possible. The warning (one often attributed to Peter Drucker) we offer educators eager for this opportunity is that such efforts need to include a reliable, efficient means of assessing the student experience, because "If you don't measure it, you cannot sustainably improve it".

8 References

- Ainley, M. (2019). Curiosity and interest: Emergence and divergence. *Educational Psychology Review*, 39, 1–18. <http://doi.org/10.1007/s10648-019-09495-z>
- Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal Educational Psychology*, 94, 545–561. <http://doi.org/10.1037/0022-0663.94.3.545>
- Alexander, P. A. (2003). The development of expertise: The journey from acclimation to proficiency. *Educational Researcher*, 32, 10–14. <https://doi.org/10.3102/0013189X032008010>
- Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology*, 84, 261–267. <http://doi.org/10.1037/0022-0663.84.3.261>
- Ausubel, D. P., Novak, J. D., & Hanesian, H. (1968). *Educational psychology: A cognitive view*. Holt, Rinehart and Winston.
- Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, 28, 117–148. http://doi.org/10.1207/s15326985ep2802_3
- Bandura, A. (1997). *Self-Efficacy: The exercise of control*. Freeman.
- Bell, L. & Lygo-Baker, S. (2019) Student-centred learning: a small-scale study of a peer-learning experience in undergraduate translation classes. *The Language Learning Journal*, 47, 299–312, <http://doi.org/10.1080/09571736.2016.1278030>
- Bergin, D. A. (1999). Influences on classroom interest. *Educational Psychologist*, 34, 87–98. http://doi.org/10.1207/s15326985ep3402_2
- Bergin, D., Bergin, C. C., Dover, T. V., & Murphy, B. (2013). Learn more show what you know. *Phi Delta Kappan*, 95, 54–60. <http://doi.org/10.1177/003172171309500110>
- Bergin, D. A. (2016). Social Influences on Interest. *Educational Psychologist*, 51, 7–22. <http://doi.org/10.1080/00461520.2015.1133306>

- Boud, D., Cohen, R., & Sampson, J. (2014). *Peer learning in higher education: Learning from and with each other*. Routledge.
- Butz, A., Branchaw, J., Pfund, C., Byars-Winston, A., & Leverett, P. (2018). Promoting STEM trainee research self-efficacy: A mentor training intervention. *Understanding Interventions*, 9, 3730. Permanent Online Location: <https://www.understandinginterventionsjournal.org/article/3730-promoting-stem-trainee-research-self-efficacy-a-mentor-training-intervention>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale N Erlbaum.
- Denissen, J.J.A., Zarrett, N. R., & Eccles, J. S. (2007). I like to do it, I'm able, and I know I am: Longitudinal couplings between domain-specific achievement, self-concept, and interest. *Child Development*, 78, 430-447. <http://10.1111/j.1467-8624.2007.01007.x>
- Devellis, R.F. (2012). *Scale development: Theory and application*. Sage
- Dochy, F. (1992). *Assessment of prior knowledge as a determinant for future learning: The use of prior knowledge state tests and knowledge profiles*: Centre for Educational Technology and Innovation, Open University.
- Durik, A.M., & Matarazzo, K. L. (2009). Revved up or turned off? How domain knowledge changes the relationship between perceived task complexity and task interest. *Learning and Individual Differences*, 19, 155-159. <http://doi.org/10.1016/j.lindif.2008.08.005>
- Flora, D. B., & Curran, P. J. (2004). An Empirical Evaluation of Alternative Methods of Estimation for Confirmatory Factor Analysis With Ordinal Data. *Psychological Methods*, 9, 466–491. <https://doi.org/10.1037/1082-989X.9.4.466>
- Fryer, L. K., Shum, A., Lee, A., & Lau, P. (2021). Mapping students' interest in a new domain: Connecting prior knowledge, interest, and self-efficacy with interesting tasks

- and a lasting desire to reengage. *Learning and Instruction*, 75, 101493.
<https://doi.org/10.1016/j.learninstruc.2021.101493>
- Fryer, L. K., & Bovee, H. N. (2020a). Teaching for course interest. *Studies in Higher Education*, 1–12. <https://doi.org/10.1080/03075079.2020.1712692>
- Fryer, L. K., Thompson, A., Nakao, K., Howarth, M., & Gallacher, A. (2020b). Supporting self-efficacy beliefs and interest as educational inputs and outcomes: Framing AI and Human partnered task experiences. *Learning and Individual Differences*, 80, 101850.
<https://doi.org/10.1016/j.lindif.2020.101850>
- Fryer, L. K., & Nakao, K. (2020c). The Future of Survey Self-report: An experiment contrasting Likert, VAS, Slide, and Swipe touch interfaces. *Frontline Learning Research*, 16. <https://doi.org/10.14786/flr.v8i2.502>
- Fryer, L. K. & Ainley, M. (2019a). Supporting interest in a study domain: A longitudinal test of the interplay between interest, utility-value, and competence beliefs. *Learning and Instruction*. 60, 252-262. <https://doi.org/10.1016/j.learninstruc.2017.11.002>
- Fryer, L. K. & Fryer, K. (2019b, Sept 19).情報処理装置、情報プログラムおよびこれを記録した記録媒体、ならびに情報処理方法. Patent application # 2017–165970
 Patent # 6585129 (Japan).[Dynamic touch-based interface for survey self-report;
 Translation of Japanese patent title: information processor (information technology equipment), information program and a medium for the recording, and a method of information processing].
- Fryer, L. K., & Ainley, M. (2019). Supporting interest in a study domain: A longitudinal test of the interplay between interest, utility-value, and competence beliefs. *Learning and Instruction*, 60, 252–262. <https://doi.org/10.1016/j.learninstruc.2017.11.002>
- Fryer, L. K., Ainley, M., Thompson, A., Gibson, A., & Sherlock, Z. (2017). Stimulating and sustaining interest in a language course: An experimental comparison of Chatbot and Human task partners. *Computers in Human Behavior*, 75, 461–468.
<https://doi.org/10.1016/j.chb.2017.05.045>

- Fryer, L. K., Ainley, M., & Thompson, A. (2016). Modelling the links between students' interest in a domain, the tasks they experience and their interest in a course: Isn't interest what university is all about? *Learning and Individual Differences*, 50, 157–165. <https://doi.org/10.1016/j.lindif.2016.08.011>
- Grigg, S., Perera, H. N., McIlveen, P., & Svetleff, Z. (2018). Relations among Math Self Efficacy, Interest, Intentions, and Achievement: A Social Cognitive Perspective. . *Contemporary Educational Psychology*, 53. <http://doi.org/10.1016/j.cedpsych.2018.01.007>
- Hair Jr, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2016). *A primer on partial least squares structural equation modeling (PLS-SEM)*. Sage Publications.
- Harackiewicz, J. M., & Priniski, S. J. (2017). Improving Student Outcomes in Higher Education: The science of targeted intervention. *Annual Review of Psychology*, 69. <http://doi.org/10.1146/annurev-psych-122216-011725>
- Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest Matters: The Importance of Promoting Interest in Education. *Policy Insights from the Behavioral and Brain Sciences*, 1-8 <http://doi.org/10.1177/2372732216655542>
- Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge, Taylor & Francis.
- Hewson, M. G., & Hewson, P. W. (1983). Effect of instruction using students' prior knowledge and conceptual change strategies on science learning. *Journal of Research in Science Teaching*, 20, 731-743. <https://doi.org/10.1002/tea.3660200804>
- Hidi, S., & Renninger, K. (2006). The four-phase model of interest development. *Educational Psychologist*, 41, 111-127. http://doi.org/10.1207/s15326985ep4102_4
- Hidi, S., Renninger, K., & Krapp, A. (2004). Interest, a motivational variable that combines affective and cognitive functioning. In *Motivation, emotion, and cognition:*

Integrative perspectives on intellectual functioning and development, 89-115.

Erlbaum.

Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology*, 102, 880-895. <http://doi.org/10.1037/a0019506>

Hulleman, C. S., & Harackiewicz, J. M. (2009). Promoting Interest and Performance in High School Science Classes. *Science*, 326, 1410-1412.
<http://doi.org/10.1126/science.1177067>

Jannoo, Z., Yap, B., Auchoybur, N., & Lazim, A. (2014). The effect of nonnormality on CB-SEM and PLS-SEM path estimates. *International Journal of Mathematical and Computational Sciences*, 8, 285-291.

Jonassen, D. H., & Grabowski, B. L. (2012). *Handbook of individual differences, learning, and instruction*. Routledge.

Keith, T. Z. (2015). *Multiple regression and beyond: An introduction to multiple regression and structural equation modelling* (2nd ed.). Routledge.

Knogler, M., Harackiewicz, J. M., Gegenfurtner, A., & Lewalter, D. (2015). How situational is situational interest? Investigating the longitudinal structure of situational interest. *Contemporary Educational Psychology*, 43, 39–50.
<http://doi.org/10.1016/j.cedpsych.2015.08.004>

Kopcha, T. J., & Sullivan, H. (2008). Learner preferences and prior knowledge in learner-controlled computer-based instruction. *Educational Technology Research and Development*, 56, 265-286. <https://doi.org/10.1007/s11423-007-9058-1>

Lombardi, D., Bailey, J. M., Bickel, E. S., & Burrell, S. (2018). Scaffolding scientific thinking: Students' evaluations and judgments during Earth science knowledge

- construction. *Contemporary Educational Psychology*, 54, 184–198.
<http://doi.org/10.1016/j.cedpsych.2018.06.008>
- Marsh, H. W., Trautwein, U., Lüdtke, O., Child, O. K., 2005. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Wiley Online Library*, 76, 397–416. <http://doi.org/10.1111/j.1467-8624.2005.00853.x>
- Marsh, H. W., & Craven, R. G. (2006). Reciprocal effects of self-concept and performance from a multidimensional perspective: Beyond seductive pleasure and unidimensional perspectives. *Perspectives on Psychological Science*, 1, 133-163.
<https://doi.org/10.1111/j.1745-6916.2006.00010.x>
- Marsh, H. W., Martin, A. J., Yeung, A., & Craven, R. (2016). Competence self-perceptions. In: *Handbook of competence and motivation*. New York: Guilford Press.
- Midgley, C., Kaplan, A., & Middleton, M. (2001). Performance-approach goals: Good for what, for whom, under what circumstances, and at what cost? *Journal of Educational Psychology*, 93, 77-86. <https://doi.org/10.1037//0022-0663.93.1.77>
- Nuutila, K., Tuominen, H., Tapola, A., Vainikainen, M.-P., & Niemivirta, M. (2018). Consistency, longitudinal stability, and predictions of elementary school students' task interest, success expectancy, and performance in mathematics. *Learning and Instruction*, 56, 73–83. <http://doi.org/10.1016/j.learninstruc.2018.04.003>
- Panadero, E., & Järvelä, S. (2015). Socially shared regulation of learning: A review. *European Psychologist*. 20, 190–203. <https://doi.org/10.1007/s11412-016-9238-2>
- Renninger, K. A., & Hidi, S. E. (2020). To Level the Playing Field, Develop Interest. *Policy Insights from the Behavioral and Brain Sciences*, 7, 10-18.
<https://doi.org/10.1177/2372732219864705>

- Renninger, K., Bachrach, J. E., & Hidi, S. (2018). Triggering and maintaining interest in early phases of interest development. *23, Learning, Culture and Social Interaction*.
<https://doi.org/10.1016/j.lcsi.2018.11.007>
- Renninger, K., & Hidi, S. (2011). Revisiting the conceptualization, measurement, and generation of interest. *Educational Psychologist, 46*, 168-184.
<http://doi.org/10.1080/00461520.2011.587723>
- Renninger, K., & Hidi, S. (2015). *The power of interest for motivation and engagement*. Routledge.
- Renninger, K., Hidi, S., & Krapp, A. (1992). *The role of interest in learning and development*. Psychology Press.
- Renninger, K., & Schofield, L. S. (2014). *Assessing STEM Interest as a Developmental Motivational Variable*. Paper presented at the American Educational Research Association, Philadelphia, PA.
- Renninger, K., & Su, S. (2019). Interest and Its Development, Revisited. In R. Ryan (Ed.), *The Oxford handbook of human motivation* (pp. 205-225). Oxford University Press.
- Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin, 138*, 353-387. <http://doi.org/10.1037/a0026838>
- Ringle, C.M., Wende, S. and Becker, J.-M. (2015), SmartPLS 3, SmartPLS GmbH, Boßnningstedt.
- Rotgans, J. I., & Schmidt, H. G. (2017). How individual interest influences situational interest and how both are related to knowledge acquisition: A microanalytical investigation. *The Journal of Educational Research, 111*, 530–540.
<http://doi.org/10.1080/00220671.2017.1310710>
- JMP®, 14.2.0 (1989-2020). SAS Institute Inc., Cary, NC.

- Schiefele, U. (1992). Topic interest and levels of text comprehension. In A. Renninger, S. Hidi, A. Krapp. *The role of interest in learning and development*. (pp. 151-183). Taylor Francis
- Schiefele, U., Krapp, A., & Schreyer, I. (1993). Metaanalysis of the connection between interest and scholastic achievement. *Zeitschrift Fur Entwicklungspsychologie Und Padagogische Psychologie*, 25, 120-148.
- Schneider, M., & Preckel, F. (2017). Variables associated with achievement in higher education: A systematic review of meta-analyses. *Psychological Bulletin*. 143, 565-600. <http://doi.org/10.1037/bul0000098>
- Tenenhaus, M., Vinzi, V. E., Chatelin, Y.-M., & Lauro, C. (2005). PLS path modeling. *Computational statistics data analysis*, 48, 159-205.
<https://doi.org/10.1016/j.csda.2004.03.005>
- Tobias, S. (1994). Interest, Prior Knowledge, and Learning. *Review of Educational Research*, 64, 37-5. <https://doi.org/10.3102/00346543064001037>
- Topping, K. J. (2005). Trends in Peer Learning. *Educational Psychology*, 25, 631-645.
<https://doi.org/10.1080/01443410500345172>
- Toursney, B., Doug, L., & Annette, P. (2019). The role of values in pre-service teachers' intentions for professional engagement. *Educational Psychology*, 0, 1–19.
<http://doi.org/10.1080/01443410.2018.1504892>
- Vosniadou, S. (1992). Knowledge acquisition and conceptual change. *Applied Psychology*, 41, 347-357. <https://doi.org/10.1111/j.1464-0597.1992.tb00711.x>
- Xu, J. (2018). Reciprocal effects of homework self-concept, interest, effort, and math achievement. *Contemporary Educational Psychology*, 55, 42–52.
<http://doi.org/10.1016/j.cedpsych.2018.09.002>

Zentall, T. R., & Galef Jr, B. G. (Eds.). (2013). *Social learning: Psychological and biological perspectives*. Psychology Press.

Figure 5. Study 1 (Science and Mass Media)

Note: All presented Betas $p < .05$

Figure 6. Study 3 (Scientific Revolutions)

Note: All presented Betas $p < .05$

Figure 7. Study 3 (Statistics and Society)

Note: All presented Betas $p < .05$

Figure 8. Study 4 (Physics)

Note: All presented Betas $p < .05$

9 Appendices

Table 1. Gender and Faculties of students for each of the four courses researched

	Scientific Revolution	Science and Mass Media	Statistics and Society	Introduction to Physics
Gender				
Male	26	16	50	66
Female	28	35	23	33
Specifically neither	2	0	1	1
Faculties				
Architecture	2	1	4	6
Arts	6	12	2	1
Business and Economics	10	18	19	9
Dentistry	2	1	0	1
Education	2	4	4	1
Engineering	11	0	19	55
Law	1	3	1	1
Medicine	8	3	3	6
Science	7	1	18	15
Social Sciences	5	8	4	5
<i>n</i>	54	57	72	100

note: six students did not report Gender and Faculty for Science and Mass Media course study.

Figure 1. Study 1 Research Design

Note: Vertical rectangles represent a single class experience usually 90 mins

Figure 2. Study 2 Research Design

Note: Vertical rectangles represent a single class experience usually 90 mins

Figure 3. Study 3 Research Design

Note: Vertical rectangles represent a single class experience usually 90 mins

Figure 4. Study 4 Research Design

Note: Vertical rectangles represent a single class experience usually 90 mins

Table 2. Study 1 Science and Mass Media pairwise correlations, reliability, means and standard deviations

	Prior Knowledge	Prior Domain Interest	Think-Pair-Share	Presentations	Course Interest
Prior Knowledge					
Prior Domain Interest	.04				
Think-Pair-Share	-.19	.12			
Presentations	.08	.08	.03		
Course Interest	-.12	.32**	.22	.41**	
Composite reliability		.91	.93	.94	.93
Average Variance Extracted		.66	.81	.83	.81
Mean	3.00	1.97	3.63	3.62	3.23
Std Dev	1.02	0.82	0.61	0.69	0.82

Note: ** = $p < .01$

Table 3. Study 2 Scientific Revolution pairwise correlations, reliability, means and standard deviations

	Prior Domain Interest	Prior Knowledge	Modelling Activity 1	Group Game	Modelling activity 2
Prior Domain Interest					
Prior Knowledge	-.02				
Modelling Activity 1	.16	.23*			
Group Game	.13	.29*	.54**		
Modelling activity 2	.31*	.20*	.60**	.76*	
Composite reliability	.91		.95	.94	.95
Average Variance	.68		.86	.83	.86
Mean	2.51	3.73	3.64	3.79	3.86
Std Dev	.92	1.39	1.04	.83	.78

Note: * = $p < .05$; ** = $p < .01$

Table 5. Study 3, Statistics and Society pairwise correlations, reliability, means and standard deviations

	Prior Interest	Prior Knowledge	Short Lecture + Discussion	Short Lecture	WorkSheet Regression	Video WorkSheet Gapminder	Course Interest
Prior Interest							
Prior Knowledge	.05						
Short Lecture + Discussion	-.04	-.16					
Short Lecture	-.03	-.11	.54**				
WorkSheet Regression	-.16	-.13	.53**	.51**			
Video WorkSheet Gapminder	-.21	-.20	.40**	.66**	.65**		
Course Interest	-.12	-.20	.45**	.48**	.70**	.66**	
Composite reliability	.88		.95	.95	.96	.97	.83
Average Variance Extracted	.59		.83	.86	.89	.91	.83
Mean	1.93	3.23	3.48	3.67	3.58	3.79	3.60
Std Dev	.91	1.14	.81	.78	.96	.92	.85

Note: * = $p < .05$; ** = $p < .01$

Table 6. Study 4. Introductions to Physics pairwise correlations, reliability, means and standard deviations

	Prior interest	Prior knowledge	Paired Discussion (Free Fall)	Paired Discussion (Circular Motion)	Short lecture (Centripetal Forces)	Paired Discussion (Car Wheels)	Writing Exercise (Linear Momentum)	Short Lecture (semi- conductor)	Post Domain Interest
Prior interest									
Prior knowledge	.26*								
Paired Discussion (Free Fall)	.22*	-.08							
Paired Discussion (Circular Motion)	.05*	.02	.48*						
Short lecture (Centripetal Forces)	.15	.04	.54*	.70*					
Paired Discussion (Car Wheels)	.17	.20*	.48*	.60*	.68*				
Writing Exercise (Linear Momentum)	.15	-.03	.49*	.42*	.46*	.53*			
Short Lecture (semi-conductor)	.03	.16	.38*	.43*	.43*	.51*	.61*		
Post Domain Interest	.55**	.27*	.35*	.38*	.37*	.45*	.32*	.16*	
Composite Reliability	.88		.86	.95	.93	.95	.97	.93	.87
Average Variance Extracted	.60		.67	.85	.82	.85	.92	.82	.58
Mean	2.71	3.75	3.84	3.95	3.64	4.13	3.68	4.01	3.52
Std Dev	.79	1.69	.68	.66	.87	.55	.83	.64	.77

Note: * = $p < .05$; ** = $p < .01$

Table 6. Average attendance for the Courses tutorials

Course	Course enrolment	Average Attendance
Study 1: CCST9022 – Mass Media,	117	85%
Study 2: CCST9026 – Scientific Revolutions	116	75%
Study 3: CCST9039 – Statistics in our Society	118	80%
Study 4: CCST9056 – The Force is With You: How Things Work	120	90%

Supplemental Materials 10

Prior knowledge tests and distribution of achievement

Study 1: CCST9022 – Mass Media : Respondents: 117

Distribution (score out of 5: percentage), 0: 1.71%, 1: 7.69%, 2: 25.64%, 3: 30.77%, 4: 29.91%, 5: 5.13%

Question 1: Which of the following is not a valid hypothesis? (69.5% correct)

- A) Male giraffes mate with one another to display dominance
- B) Fluoride protects teeth from decay
- C) Red wine reduces risk of heart disease
- D) Channing Tatum is attractive**

Question 2: Which of the following presents the least potential bias in scientific research? (76.3% correct)

- A) Toothpaste study funded by Colgate
- B) Climate change study performed by a university**
- C) Removal of data that does not align with hypothesis
- D) Direct payment for publishing interesting results
- E) Reverberation (think singing karaoke) and echoes happen for the same reason.

Question 3: Which of the following is an example of pseudoscience? (58.5% correct)

- A) Acupuncture**
- B) Antibiotics
- C) Astronomy
- D) Geology

Question 4: In a scientific study, what is the meaning of $p < .05$? (29.7% correct)

- A) A common threshold of significance**
- B) A measure for the gradient of a correlation

- C) The prediction ratio
- D) Atmospheric pressure at high altitude is less than 5% of the pressure at sea level

Question 5: Which of the following is a common problem in the reporting of science in the media? (60.2% correct)

- A) Exaggeration of results**
- B) Presentation of too many statistics
- C) Over-reliance on interviews with scientists
- D) Bribing of journalists for better coverage

Study 2: CCST9026 – Scientific Revolutions (NOT PRIOR KNOWLEDGE, called ACH4 or ACHt4 in the report. It's a short test a few lessons in)

81 participants

Distribution (score out of 6: percentage),

0: 2.47%, 1: 0%, 2: 12.34%, 3: 29.63%, 4: 27.16%, 5: 14.81%, 6: 13.58%

Question 1-6: In this case an example of induction or deduction? Correct Answers:

- 1) Induction (63% correct), 2) Induction (79% correct), 3) Induction (49.4% correct), 4) Deduction (69% correct), 5) Deduction (51.9% correct), 6) Deduction (65.4% correct)

Not sure if you want George's actual sheet of questions...This isn't a prior knowledge measurement anyway.

Study 3: CCST9039 – Statistics in our Society: 104 participants

Distribution (score out of 5: percentage), 0: 0.96%, 1: 4.81%, 2: 19.23%, 3: 32.69%, 4: 30.77%, 5: 11.54%

Question 1: Which descriptive statistics is used to derive the following process? Sort the values of a variable from smallest to largest and select the value in the centre. (85.6% correct)

- A) Centre

- B) Mean
- C) Median**
- D) 1st Quartile
- E) Average

Question 2: Which of the following is the purpose of a boxplot? (30.8% correct)

- A) Evaluate the spread of a variable
- B) Compare the spread of data between categories**
- C) Evaluate a variable over time
- D) Determine a correlation between two continuous data points
- E) Compare the mean of variables

Question 3: Which of the following is true? (71.2% correct)

- A) Political polls are sampled from a truly random sample
- B) Political polls are accurate because they randomly call landline phones
- C) Online polls are good representations of the general population
- D) Political polls are hard to predict close election results as they are rarely precise enough.**

Question 4: Researchers have found a negative correlation between eating chilli and death. What can be inferred from this? (64.4% correct)

- A) Eating chilli protects people from dying.
- B) Eating chilli may reduce the risk of dying.**
- C) Eating chilli can kill people
- D) People who eat chilli also eat healthier and therefore die less frequently
- E) Eating chilli does not have any effect on your health.

Question 5: Which of the following is true of the Consumer Price Index (CPI)? (70.2% correct)

- A) CPI is a useful estimation of inflation**
- B) CPI is a useful estimation of consumer confidence in the economy
- C) CPI is not at all useful
- D) CPI uses food only to track changes in food prices

Study 4: CCST9056 – Physics: Respondents: 119

Distribution (score out of 6: percentage), 0: 4.20%, 1: 5.88%, 2: 14.29%, 3: 19.33%, 4: 14.29%, 5: 24.37%, 6: 17.65%

Question 1: An airplane travelling from left to right drops a bowling ball. The bowling ball's trajectory most closely matches which path?
(75.6% correct)

A), B), C), **D**), E)

Question 2: If a puck slides on a frictionless surface from a to b, and it receives a kick at “b” head on, with no spin, in the direction of the big arrow, what is the path of the puck afterwards? (58.0% correct)

A), **B**), C), D), E)

Question 3: Describe the speed of the puck after the kick. (63.0% correct)

- A) Equal to the speed " v_0 " it had before it received the kick.
- B) Equal to the speed " v_k " resulting from the kick and independent of the speed " v_0 ".
- C) Equal to the arithmetic sum of the speeds " v_0 " and " v_k ".
- D) Smaller than either of the speeds " v_0 " or " v_k ".
- E) Greater than either of the speeds " v_0 " or " v_k " but less than the arithmetic sum of these two speeds.**

Question 4: A woman pushes a box with a force that causes it to move at constant velocity. The force applied on the box... (78.2% correct)

- A) Has the same magnitude as the weight of the box.
- B) Is greater than the weight of the box.
- C) Has the same magnitude as the force which resists the motion of the box.**
- D) Is greater than the total force which resists the motion of the box.
- E) Greater than either the weight of the box or the force which resists its motion.

Question 5: If the applied force is doubled, the speed of the box will be... (53.8% correct)

- A) Constant and doubled " v_0 " (the original speed).
- B) Constant, greater than " v_0 " but not necessarily twice as great.
- C) Constant and greater than " v_0 " for a while, then with a speed that increases after.
- D) For a while with an increasing speed, then with a constant speed thereafter.
- E) With a continuously increasing speed.**

Question 6: If the woman stops applying any force, the box will... (48.7% correct)

- A) Immediately come to a stop.
- B) Continue moving at a constant speed for a while and then slow to a stop.
- C) Immediately start slowing to a stop.**
- D) Continue at a constant speed.
- E) Increase its speed for a while and then start slowing to a stop.