Secondary School Students' Use of and Attitudes toward Online Mathematics Homework

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Biography
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ABSTRACT
The purposes of this study were twofold: 1) to examine the influence of performance expectancy, and effort expectancy on secondary school students attitudes toward the use of a mathematics online homework package called MyiMaths; and 2) to predict the factor that best influences their attitudes. A 15 item, five-point Likert-scale instrument was administered to 345 secondary school students, and data were analyzed using the Partial Least Squares-Structured Equation Modeling (PLS-SEM) approach. Findings revealed that there were significant relationships between performance expectancy, effort expectancy, and student attitude toward the use of an online mathematics homework tool. The findings also indicated a positive relationship between student attitudes and their actual use of online homework. Additionally, performance expectancy was found to be the best factor for predicting student attitude toward the use of online homework. The outcomes of this study will enable educators to design appropriate teaching and learning interventions for their students.

Keywords: Attitude; Mathematics; Online homework; Online learning; Web-based learning

INTRODUCTION
Online homework (OHW), considered to be an effective alternative method to traditional homework (Riffell & Sibley, 2005). The use of web-based or OHW has become a new trend for complementing traditional paper-and-pencil assignments in the teaching and learning of mathematics (Locklear, 2012). The aim of using OHW tools is to enable students to complete and submit their homework assignments online and to receive immediate feedback. OHW makes students more actively engaged in learning activities, leading to better overall performance. Students are able to work anywhere with the help of online tutorials by receiving instant online feedback (Gates, 2014).

Research on the use of OHW tools has grown significantly in education environments due to the advantages provided by this technology. Very few studies, however, have reported definite empirical evidence either in favor of the use of OHW tools or against such use (Cox and Singer, 2011, Wooten and Dillard-Eggers, 2013). For example, Lenz (2010) found high levels of perceived learning for students who used OHW systems but failed to prove that exam grades improved significantly. Therefore, more studies should be conducted to provide clear, practical evidence for understanding the influence of using OHW tools.

Furthermore, existing research studies related to OHW have been directed toward higher education learners such as Peng (2009) who studied online homework with 61 participants in a college accounting course in the University of Michigan; Cox and Singer (2011), who investigated OHW used in four sections of college calculus (n=87). What would happen if OHW were to be used in more structured learning environments such as in secondary schools, which factors should be given the most consideration?

OBJECTIVES AND RESEARCH QUESTIONS
The first aim of this study was to examine the influence of performance expectancy, and effort expectancy on secondary school student attitudes toward the use of a mathematics OHW tool called MyiMaths. The second purpose of this study was to predict the most significant factor that influences students' attitudes toward the use of this tool.

The framework of this study was based on a combination of factors derived from two theories: Gilbert (2015) and the Unified Theory of Acceptance and Use of Technology (UTAUT). These provide a way to explain the impact of student attitude toward OHW on performance expectancy, and effort expectancy factors. They can also be used to predict the most important factor that influences student attitudes. This study was conducted to answer the following research questions:

1. Which factors (i.e., performance expectancy and effort expectancy) influence student's attitude toward the use of OHW for mathematics learning?
2. What is the relationship between student attitude toward the use of OHW and the actual use of OHW?
3. Which factors (i.e., performance expectancy, and effort expectancy) best predict student attitude toward the use of OHW for mathematics learning?

The next section presents literature related to OHW and its relationship with performance expectancy, effort expectancy, and attitude toward mathematics.

LITERATURE REVIEW

Homework

Homework is any task assigned to students to do outside of class to prepare them for new materials. Previous research indicates that a greater amount of homework is beneficial for improving student achievement at upper-elementary and secondary levels (Kitsantas, Cheema, & Ware, 2011).

Homework allows students to do the Mathematics rather than merely watching it being done by the professor. It allows the student to take an active role in improving their knowledge and perception of the material (Smolira, 2008). Homework is the best way to practice and develop problem solving and critical thinking skills ((Bonham, Deardorff, & Beichner, 2003; Palocsay & Stevens, 2008). Most studies that focus specifically on quantitative homework have indicated that the course grade and overall performance are positively affected by doing homework (Ramdass & Zimmerman, 2011). Bembenutty (2011) found if students receive shorter and more frequent homework, they are more likely to complete the assignments, which ultimately leads to increased achievement. Ramdass and Zimmerman (2011) studied how homework can influence the development of self-regulation skills and discussed how requiring homework influences far more than achievement.

Doing homework has a particularly positive impact on the student learning processes when it is graded. One approach that motivates students to do homework is to collect and evaluate it as homework grade which influence the students' overall final course grades (Cox, 2011). In the traditional mathematics course, it is nearly impossible for an instructor to grade all of the homework problems assigned to each student. Even if assignments are graded, feedback may not be received in time to help students adjust any incorrect thought processes prior to an exam.

Technology has produced new models for delivering mathematics instruction—including the format of homework—and the introduction of OHW is a promising way to improve the feedback process and effectiveness of homework (Lenz, 2010).

Online Homework (OHW)

The terms "web-based homework" or "online homework systems" refer to any system of computerized homework problems made to provide automatic grading and immediate feedback (Leong & Alexander, 2014). In the current study, the OHW system MyiMaths followed this definition. MyiMathis is a website for mathematics homework that can be accessed online anytime via the link http://www.myimaths.com. It includes a large bank of practices for assessing mathematics skills, taking quizzes, viewing videos, obtaining live tutorial help, and providing immediate feedback.

Researchers have documented that online homework plays an important role in students' attitude (e.g. Barnsley, 2014; Halcrow & Dunnigan, 2012; Lenz, 2010). Students have positive attitudes toward the OHW tool possibly because of the immediate feedback that help to improve student learning and understanding (Leong & Alexander, 2014). Doorn, Janssen, & O'Brien (2010) indicated in their research that 90% of students thought that online homework worked well. More than 70% of the students in this study would recommend online homework to others, as they found it beneficial to their understanding of content and exam preparation. Zerr (2007) noted that 17 of 19 calculus students strongly agreed that using the OHW was a valuable addition to the course.

Performance expectancy, effort expectancy, and attitude toward OHW
In general, students respond positively about using homework tools (Schubert, 2012). The students prefer using OHW tools if they belief that it helps them to achieve performance in learning (performance expectancy) and if using OHW is easy to use (effort expectancy).

Several studies have examined these factors on college students. Peng (2009) focused on investigating student differences in using the OHW system and how these differences impact what they gain from using this system. The finding of the study indicated that online homework could have positive effects on students, whereby most of the student participants felt that the experience was beneficial. The study also showed that the tools and motivation behind the online homework is significant to encourage students to become more successful in the Mathematics classroom.

Morgan (2013) examined the factors motivating students to use the OHW tool in the accounting class (N = 76). The finding suggested that students prefer to use an OHW when they believe that using this tool will require less effort. Students also prefer to use the OHW when they observe that their teachers and peers think that they have to use it.

THE CONCEPTUAL MODEL
The current study examines factors that influence student attitude toward using a mathematics OHW tool. The conceptual model in this paper (Figure 1) adapts student attitude toward a technology factor from Gilbert (2015) in which statements related to this factor are generated based on items found from attitude constructs in existing models (Davis, Bagozzi, & Warshaw, 1989; Fishbein & Ajzen, 1975). This factor was then combined with three factors—performance expectancy, effort expectancy, and actual use—, derived from the Unified Theory of Acceptance and Use of Technology (UTAUT), which was developed by Venkatesh, Morris, Davis, and Davis, (2003). Table 1 summarizes the sources used to operationalize the model factors.

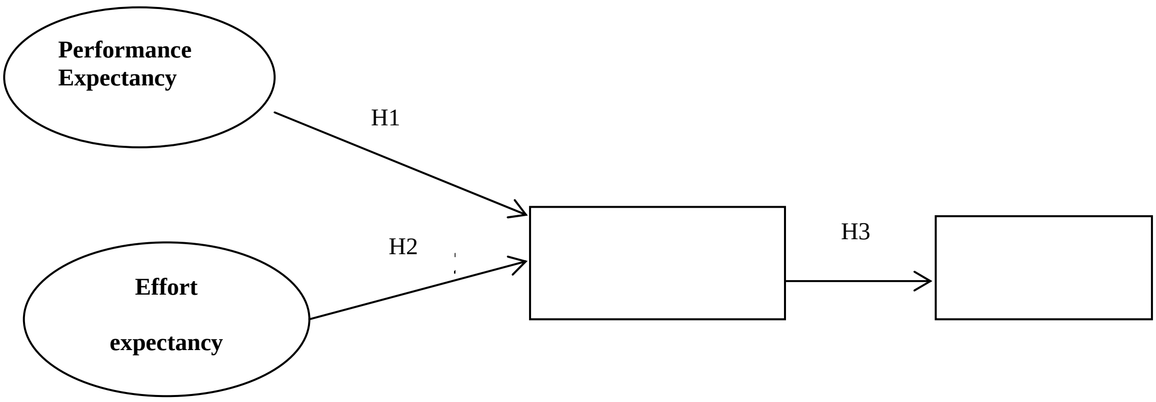

Figure 1: The proposed model

Table 1: The factors and sources

Factor	Model	Source
Performance expectancy	UTAUT	Venkatesh et al. (2003).
Effort expectancy	UTAUT	Venkatesh et al. (2003).
Attitude toward OHW	Gilbert model	Gilbert (2015), Davis, Bagozzi, & Warshaw, (1989), Fishbein & Ajzen, (1975).
Actual usage of OHW	UTAUT	Venkatesh et al. (2003).

Each of the four factors is discussed in the following sections:

Performance Expectancy
In the current study, performance expectancy factor refers to student confidence in the ability of the OHW tool to help them improve in mathematics performance and learning. Perceived usefulness, one of the important constructs of performance expectancy, has been found to influence student attitude toward the use of classroom technology (Shen and Chuang, 2010). In the current study, the relationship between performance expectancy and student attitude toward OHW was expected to be positive.

Therefore, the first research hypothesis is:
H1: Student performance expectancy is positively influenced by student attitude toward the use of OHW for mathematics learning.

Effort expectancy
Effort expectancy in this study refers to the degree to which students perceive ease of use when using the OHW tool. Students are more motivated to accept and use OHW tools if they perceive that using these tools are easy (Morgan, 2013) and vice versa.

Self-efficacy, enjoyment, and anxiety factors contribute to effort expectancy and may impact one's attitude toward using technology (Celik & Yesilyurt, 2013; Shen & Chuang, 2010). The features of the OHW tool used in this study supported these factors, so student attitude toward the OHW was expected to predict effort expectancy.

Therefore, the second research hypothesis is:
H2: Student's effort expectancy is positively influenced by student attitude toward the use of OHW for mathematics learning.

Attitude toward Using Technology
Attitude toward technology refer to positive or negative feelings about performing the target behavior (Venkatesh, 2013). The attitude toward use of technology is drawn from the attitude toward a behavior construct found in the Theory of Reasoned Action, the affective state toward use from the Model of Personal Computer Utilization, the affective state from Social Cognitive Theory, and the intrinsic motivation from Motivational Theory. All these constructs relate to an attitude conveying one's enjoyment, pleasure, and liking connected with the use of technology. Individuals accept and use technology more easily if they have positive attitudes compared with those with negative attitudes toward technology. In this study, attitude refers to students' feelings of favorability or unfavorability toward using OHW tools.

Actual Use
Actual use of technology refers to personal interests or personal evaluation of performing the system (Zanna & Rempeel, 1988). In the current study, this construct is used to assess student interest toward the OHW tool.
Numerous studies have indicated that student attitude improves with the use of technology (Edmunds, Thorpe, & Conole, 2012; Maria, Persa, Ilias, & Efstanthios, 2011; Judi, Amin, Zin, & Latih, 2011), so in the current study, student attitude toward OHW was expected to predict actual use of OHW.

Therefore, the third research hypothesis is:
H3: Student attitude toward the use of OHW is positively influenced by the actual use of OHW for mathematics learning.

METHODOLOGY
A Partial Least Squares (PLS-SEM) approach was used for the current study to examine the relationships between student attitude toward OHW and factors that motivate students to use technology (i.e., performance expectancy and effort expectancy). Then, the relationship between student attitude toward OHW and actual use of an OHW tool in secondary schools was tested.

The PLS-SEM technique was used to test the structural equation model for several reasons. First, PLS-SEM represents a causal model approach, whose purpose is to maximize the explained variance of the dependent latent variables (Hair, Sarstedt, Ringle & Mena, 2012). Second, PLS-SEM may be used for a small sample size; it works on reflective and formative models that contain multiple or single-item construct indicators (Hair, Hult, Ringle, & Sarstedt, 2014). Third, PLS-SEM is useful for predicting new or changeable phenomena and is an approach suitable for testing a theoretical model or measures that are not well-designed (Chin & Newsted, 1999). For these reasons this approach is well-suited to the purpose of this study.

Sample
The sample for this study consisted of 345 secondary students from one of the international schools in Kuala Lumpur. All students have access to the OHW tool MyiMaths, and they were able to log into their accounts and work on the mathematics homework assigned. Students were able to access their OHW at any time using a computer with an Internet connection to complete their weekly assignments.

Data collection

A 15-item survey with questions scored on a five-point Likert scale was administered to 345 secondary school students. The survey contained two parts: Part 1 included demographic information, and the students were asked about their gender, age group, and ethnicity. Part 2 included a set of questions that proportionally represented student opinions about the OHW tool. The questionnaire in this instrument is valid and reliable, the subscale internal consistency ranging from 0.772 to 0.781.

FINDINGS

Two-stage analytical procedures were used to assess the model. First, the measurement model was tested, and then, the hypotheses and relationships for the structural model were examined (Anderson & Gerbing, 1988).

Stage 1: Assessing the measurement model

The first step of the assessment procedure of a reflective measurement model is factor loading, the correlation between the observed value and the latent value of a factor (Vinzi, Chin, Henseler, &Wang, 2010). Next is measuring internal consistency to estimate reliability based on the different outer loadings of the indicator variables. Convergent validity and discriminant validity were examined to evaluate the measurement model. Table 2 shows the latent and manifest variables that were used to run measurement and structural model analyses.

Table 2: Properties of Measurement Constructs

CONSTRUCT	ITEMS	Measurement Variables	LOADINGS	AVE	CR
Attitude toward use of OHW	AT1	Using MyiMaths is considered a good idea.	0.779	0.735	0.917
	AT2	Learning Mathematics using MyiMaths is more interesting.	0.893		
	AT3	Learning Mathematics using MyiMaths is fun.	0.873		
	AT4	I like learning with MyiMaths for this course.	0.879		
Actual use of OHW	AU1	I use the MyiMaths when learning in class.	0.700	0.666	0.856
	AU2	I have used MyiMaths a lot in the past 4 weeks.	0.885		
	AU3	I have been using MyiMaths regularly in my study.	0.850		
Effort Expectancy	EE1	My interactions with MyiMaths are strong and understandable.	0.784	0.623	0.869
	EE2	For me, it is easy to develop my skills at using MyiMaths.	0.767		
	EE3	For me, it's easy to learn how to operate MyiMaths.	0.835		
	EE4	I found using MyiMaths is easy.	0.770		
Performance Expectancy	P1	I find MyiMaths valuable in learning Mathematics.	0.785	0.62	0.867
	P2	Using MyiMaths allows me learning Mathematics quickly.	0.734		
	P3	Using MyiMaths enables me to increase my productivity in Mathematics.	0.822		
	P4	Using MyiMaths enables me to increase my chances to get a good grade in Math.	0.806		

Note: AVE = Average Variance Extracted; CR = Composite Reliability

The evaluation of construct reliability was performed by examining the composite reliability. The composite reliability for the constructs was > 0.85, considerably greater than the suggested minimum level of 0.7. The loading factors were all higher than 0.5, and the AVE values were also above 0.5. The results for the research's measurement model, as suggested by Hair, et al., (2014) show that all factors satisfy this criterion; thus, it is reliable and demonstrates adequate convergent validity.

To assess the discriminant validity, the heterotrait-monotrait (HTMT) criteria was calculated. Table 3 displays the result of this analysis.

Table 3: The Heterotrait-Monotrait (HTMT) Analysis

	AU	AT	EE	PE
AU				
AT	0.800 CI.90 (0.706,0.0.884)			
EE	0.588 CI.90 (0.472, 0.700)	0.609 CI.90 (0.466, 0.751)		
PE	0.776 CI.90 (0.658, 0.884)	0.703 CI.90 (0.596, 0.796)	0.786 CI.90 (0.697, 0.869)	

Note: AU: Actual use, AT: Attitude, EE: Effort expectancy, PE: performance expectance.

The analysis showed that all values were greater than the HTMT 0.90 criterion (Gold, et al., 2001) and the HTMT 0.85 criterion (Kline, 2011), and there was no value of 1 for the confidence interval for the factors. These findings indicate that each factor is unique and that there were no discriminant validity issues. In sum, the evaluation of the measurement model suggested the sufficiency of both convergent and discriminant validity, so it was appropriate to proceed with the evaluation of the structural model.

Stage 2: Assessing the structural model

Stage 2a: Assessment of the Coefficient of determination (R^2) and Predictive relevance (Q^2)

The R-square (R^2) value indicates the amount of variance explained by the dependent variables that were used to evaluate the structural models' predictive power. Table 4 displays the values of R^2 and Q^2.

Table 4: The values of R^2 and Q^2

hypotheses	Relationship	R^2	Q^2
H1	Performance expectancy -> Attitude	0.404	0.289
H2	Effort expectancy -> Attitude		
H3	Attitude -> Actual Use	0.421	0.273

The R^2 value is 0.404, indicating that the factors (performance expectancy, effort expectancy) explain 40.4% of the variance in student attitude toward OHW, and attitude toward OHW explains 42.1% of the variance in actual use of OHW. An R^2 of a value higher than 0.26 suggests that the model is substantial (Cohen, 1988).

A blindfolded procedure analysis was used to measure the predictive relevance (Q^2) of the model. This analysis was used only for endogenous constructs with reflective measurement (Hair, et al., 2014). Referring to Table 3, the Q^2 values are (0.273 and 0.289) >0, indicating that the model has adequate predictive relevance. Additionally, the results Q^2 (0.273 and 0.289) >0.15 demonstrate that the exogenous construct has medium predictive relevance for a certain endogenous construct (Hair, et al., 2014).

Stage 2b: Assessment of Path Coefficients

A bootstrapping procedure with 5,000 resamples was executed to obtain the t-values and evaluate the significance of the hypotheses of the study. Table 5 displays the bootstrapping results.

Table 5: Bootstrapping result and Hypotheses Testing

Hypotheses	Relationship	Std Beta	Std Error	T-value	P-value	Supported
H1	Performance expectancy -> Attitude	0.455	0.062	7.386**	0.000	Yes
H2	Effort expectancy -> Attitude	0.225	0.078	2.888**	0.004	Yes
H3	Attitude -> Actual Use	0.648	0.038	17.042**	0.000	Yes

Note: (t-values > 1.645 where p< 0.05), (t-values > 2.33** where p< 0.01)*

According to Table 5 the predictors of student attitude toward the use of OHW performance expectancy (β = 0.455, p <0.01), and effort expectancy (β = 0.225, p <0.05) were all positively related to attitude toward OHW, so H1and H2 were supported.
We next looked at the predictor of the actual use of OHW. Student attitude toward OHW (β = 0.648, p <0.01) was positively related to actual use of OHW, so H3 was also supported.

Stage 2c: Assessment of the Effect sizes (f^2)
The results of the f^2 are displayed in Table 6.

Table 6: Results of the f^2 effect sizes

Hypotheses	Relationship	Effect Size (f^2)	Effect Size
H1	Performance expectancy -> Attitude	**0.207**	medium
H2	effort expectancy -> Attitude	0.05	small
H3	Attitude -> Actual Use	0.726	large

The effect sizes were determined to be 0.02, 0.15, and 0.35, or small, medium, and large effects, respectively (Cohen, 1988). With reference to Table 4, H1 relationship had a medium effect size, H2 had a relationship with small effects, and the H3 relationship had a large effect size, so f^2 values for (H1, H2, and H3) relationships demonstrated substantive impact.

DISCUSSION

This study investigated factors influencing the attitudes of secondary school students toward the use of online mathematics homework. The study combines attitude factor from Gilbert (2015) with some factors from the UTAUT model as a way to explain the relationship between these factors and students attitude toward the use of OHW for learning mathematics. The literature points to the need for identifying factors that can positively influence student achievement (Falco, Summers, & Bauman, 2010; Fast, et al., 2010). Performance expectancy and effort expectancy are factors that could change how students perform in the classroom and how they view themselves as capable learners of mathematics through online homework tools.
From the proposed hypotheses, H1, H2 and H3 were supported as having a direct relationship with student attitude toward OHW.

The relationship between student performance expectancy and attitude toward the use of OHW

The result of this hypothesis revealed a strong and positive relationship between student performance expectancy and attitude toward the use of OHW for mathematics learning. When students have a clear understanding that using OHW can help them attain gains in mathematics learning, their attitude toward using it will be improved. The finding of this hypothesis supports the Gilbert (2015) study, which found that performance expectancy significantly contributes to student attitudes toward technology.

The relationship between student effort expectancy and attitude toward the use of OHW

The finding of this hypothesis revealed that student effort expectancy was positively influenced by student attitude toward OHW for mathematics learning. Students who perceived the OHW tool to be easy to use had a more favorable attitude toward using it. The finding of this hypothesis is consistent with the Morgan (2013) study indicating that students prefer to use OHW systems when they believe that using them requires less effort. The finding of this hypothesis is also supported by existing literature indicating that effort expectancy significantly predicts student attitude toward technology (Celik & Yesilyurt, 2013; Gilbert, 2015; Shen & Chuang, 2010).

The relationship between attitude toward the use of OHW and the actual use of OHW

For the second research question, the results indicated a strong positive relationship between attitude toward OHW and actual use of OHW. Student attitude toward OHW improved positively when students used OHW in class or when it was assigned for practice outside of class. This finding of the hypothesis is supported by research suggesting that student attitude improves with the use of technology (Edmunds, et al., 2012; Judi, et al., 2011; Maria, et al., 2011).

The factors that best predict student attitude toward the use of OHW

For the third research question, an effect-sizes technique using the PLS-SEM structural model analysis was executed to determine the factor that most influenced student attitude toward the use of OHW for mathematics learning. The findings revealed that effect size for performance expectancy (f^2=0.207) was the best predictor of student attitude toward OHW. Effect size for the effort expectancy was (f^2=0.05) which has the small effect for predicting student attitude toward the use of OHW. This finding is especially important for OHW developers, who can determine specific interventions that will help increase performance expectancy.

CONCLUSION

In summary, a positive relationship was found between performance expectancy, effort expectancy, and attitude toward the use of OHW. There was a positive relationship between attitude toward OHW and actual use of OHW. Performance expectancy was the best predictor of student attitude toward the use of OHW.

Future studies should explore whether student attitude toward the use of OHW in these settings influences student achievement, motivation, or improvement in student attitude toward mathematics in general. In addition, more studies could be performed to confirm and expand current findings for a larger sample of participants who are more representative of the whole population of secondary school students. Another interesting study could focus more on the effect of the instructor on using OHW and consider this factor as an independent variable. Research should examine the relationship between instructor attitude toward OHW and student attitude. Instructors who prefer using OHW tools should be studied in comparison to instructors who reject to their use to obtain a more complete picture about the impact of OHW tools.

Negative student attitudes toward mathematics increased as the grade level increased. The Adelson and McCoach (2011) study stated that students in lower grades enjoyed mathematics more than those in the upper grades. Students with negative attitudes toward mathematics in high school took fewer math courses in college. In this regard, it is necessary to encourage students to develop positive attitudes toward mathematics at the secondary education level by, for example, using online technologies such as OHW to help improve students' attitudes toward mathematics and to encourage them to work harder at mathematics (Avci, 2012).

The findings of this study should be useful to Mathematics instructors to encourage them to adopt online homework tools as an instructional and assessment tool for increasing students' attitude toward learning Mathematics. The finding is especially important for OHW developers, who can determine specific interventions that help to improve students' attitude toward mathematics.

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Statements on open data, ethics and conflict of interest

Data for this study will be stored in an institutional repository and can be accessed by public. Participants of this study have given their consent to participate in data collection processes and consent for authors to publish the findings.

The following procedures were undertaken to ensure confidentiality:

- Only the Principal Investigator (PI) had access to the raw data; and
- All identifiers were removed from raw data and replaced with unique ID only known to the PI.

Other than funding received, this work has no other potential conflict of interest.

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