Extending Perceived Navigational Risk and Technology Acceptance Model to Electronic Chart Display and Information System

SHENG-FEI HSU
Center for General Education
National Formosa University
No.64, Wunhua Road, Huwei Township, Yunlin County 632
TAIWAN
g9320803@yuntech.edu.tw

YU-WEI HSU
Department of Information Systems and Operations Management,
University of Auckland
12 Grafton Road, Auckland
NEW ZEALAND
yhsu026@auckland.ac.nz

Abstract: - Seafarers' doubting about the electronic chart display and information system is a widespread problem. To better explain, predict, and increase user acceptance, this research focused on the impact of navigational risks to address and predict shipmates' computer acceptance by a measure of their intentions, attitudes, perceived usefulness, and perceived ease of use. Thus a hypothesized model was proposed to examine the relationships between the related constructs by comparing experienced shipmates with non-experienced marine college students. Study verified that the perceived navigational risk had negative effect on perceived usefulness and perceived ease of use, and also indicated its further influence on the perception on technology acceptance. These results may provide important references for manufacturers and marine college to adjust further products, or enhance the training course on information literacy and the ability of manipulating modern navigational information system.

Key-Words: - Electronic chart display and information system (ECDIS), Technology acceptance model (TAM), Perceived navigational risk, Perceived ease of use, Perceived usefulness, Structure equation modeling.

1 Introduction

Following the remarkable technological advance, people expect that such advancement can improve current unsatisfied accuracy, efficiency and effectiveness. Similar expectance also appears in the marine transportation. While seafarers charted the seas using sun, moon, and the stars before, modern shipmates can estimate ship's position by electronic chart display and information system (ECDIS). ECDIS is a computer-based navigation information system that complies with International Maritime Organization (IMO) regulations and can be used as an alternative to paper nautical charts. The ECDIS installs electronic navigational charts (ENC) and integrates position information from the global positioning system (GPS), as well as other navigational sensors, such as radar and automatic identification systems (AIS). This complex system allows not only route recommendations and position tracking, but also generating audible and/or visual alarms when the vessel is in proximity to navigational hazards.

However, for all its capacity, some technical limitations and navigational risk still exist, these faults as well as shipmate's experiences can make precise ECDIS unable to substitute the conventional tools, or even just become one of auxiliary navigational instruments, especially in offshore sailing. Accordingly, shipmate has to regularly check ship's position by the conventional tools, such as sextant and magnetic compass, to confirm ECDIS in normal operating condition. Just as previous researches suggested that the electronic chart should not be totally relied upon or lead the shipmate into a false sense on safety and security [1]. Prior study also advised that over-confidence must not result from the fact that the ship's position was automatically shown on a chart [2]. In other words, shipmate must be always wary as to how the system is actually performing in regard to accuracy and reliability. Unfortunately, although applying ECDIS

on the ship gradually became an important issue, there was still no sufficient empirical study to investigate seafarers' perception and cognition on accepting and manipulating these modern informational systems under the threats of navigational risk. For filling this gap, this study focused on examining and predicting the acceptance of such an advanced navigational instrument under the potential influence from navigational risk. In addition, both technology acceptance model (TAM) and the perception of perceived navigational risk were used in this research.

The purpose of TAM was to explain and predict the acceptance of information technology based on two specific behavioral beliefs: perceived ease of use (PEOU) and perceived usefulness (PU) [3]. And perceived navigational risk was applied on probing the influence of negative uncertainty on shipmate's behavior. The ambition of this study was to provide important references to adjust manufacturers' future products, and enhance training course of marine college on information literacy and the ability of manipulating modern navigational information system.

This investigation carried out by comparing experienced shipmates with marine college students without practical experience on ship. In addition, structural equation modeling (SEM), a statistical technique for testing and estimating causal, was used to analyze the related data collected by questionnaire.

2 Literature review

A shipmate in bridge had three main duties: navigation, collision avoidance, and ship management. For completing these jobs efficiently, ECDIS was designed to reduce the time spent on navigation by eliminating manual data processing and providing the shipmate with a display which aided him/her in quickly evaluating the navigation picture [2]. Although the IMO also proposed performance standards for ECDIS [4], navigational risk still existed and affected shipmate's perception and attitude on manipulating this system. The hazards associated with the use of ECDIS fell into three categories [1]: Firstly, the equipment itself, both hardware and software, might suffer potential virus infection, power outages, or loss of input of sensory equipment. Secondly, the charts themselves were at risk from permit expiry, out-of-date charts being used, updates not applied correctly, excessive zooming (in the case of Raster charts), inability to open the next chart required. And thirdly, the particulars of these risks were unique to each vessel, crew and equipment, and could only be assessed on a case-by-case basis.

According to previous research, risk was described as the likelihood of the hazard occurring, combined with the severity of the hazardous event [5]. Cunningham [6] defined risk as "the amount that would be lost if the consequences of an act were not favorable". And Harland et al. stated that risk was associated with the "change of danger, damage, loss, injury or any other undesired consequences" [7]. Perceived risk was introduced in the 1960s, it has been modeled as both a two-dimensional construct (i.e., uncertainty and negative consequences) [8][9]. Based on and developed from Harland et al's definition, this study defined perceived navigational risk on ECDIS as perceived negative variation of danger, damage, loss, injury or any other undesired consequences of using ECDIS on the voyage.

The TAM model was an influential extension of Fishbein and Ajzen's theory of reasoned action (TRA). TAM used TRA as a theoretical basis for specifying the causal linkages between the two key features: perceived usefulness and perceived ease of use, and users' attitudes, intentions and actual computer adoption behavior [3]. TAM was considerably less general than TRA, but it was readily extended to apply to any type of technology by two specific variables, perceived usefulness and perceived ease of use, which were hypothesized to be fundamental determinants of user acceptance [10]. The goal of the model was to provide an explanation of the determinants of computer acceptance by tracing the impact of external factors on internal beliefs, attitudes and intentions.

Prior studies explained that external factors were the connection between the inner belief, attitude, intention, and controllable behavior [3]. And previous researches have listed various external factors for examining different situations [11][12]. In addition, the unified theory of acceptance and use of technology (UTAUT), proposed by Venkatesh et al. [13], extended TAM to take into account several new constructs (Performance Expectancy, Effort Expectancy, and Social Influence) that bore significant influence on behavioral intention and ultimately usage of technologies. However, external factors in this study was represented by perceived navigational risk, which was not just a theoretical term, or a measure of performance or effort. On the contrary, various risks were never absent on shipmate's routine works and always had huge influences on seafarers' intention and attitude on using navigational instruments such as ECDIS.

3 Hypotheses and methodology

For analyzing how the perceived navigational risk affected shipmate's perception and behavioral intention on using ECDIS, several hypotheses were proposed for measuring and illustrating the effects between potential navigational risk and technology acceptance.

3.1 Hypotheses

False information or malfunction on ECDIS might cause inaccurate ship manoeuvring, or even disastrous wreckage. Therefore, despite the well-known benefits of electronic nautical charts over paper charts, the maritime community has been rather slow to adopt ECDIS due to the navigational risk on the limitations of ECDIS, and such phenomenon also appeared on the shipmates [2]. Further, the application of risk assessment has been used for a number of years to assist in safety procedures in various aspects of the running of a vessel. But, until now, it has not been extended specifically to ECDIS and all its functions [1]. These negative navigational factors would seriously increase shipmate's doubt on ECDIS's ease of use and usefulness. Prior researches also indicated that perceived risk or loss would negatively influence users' perceived usefulness and perceived ease of use [14][15][16]. Then, according to the potential negative influences from ECDIS and its relationship with shipmate's perception on usefulness and ease of use, the first two hypotheses were proposed:

Hypothesis H1: Perceived navigational risk on ECDIS had significant negative impact on perceived usefulness.

Hypothesis H2: Perceived navigational risk on ECDIS had significant negative impact on perceived ease of use.

In TAM, perceived usefulness reflected task-related productivity, performance, and effectiveness. And perceived ease of use referred to the degree to which the user expected the target system to be free from effort [10]. Many studies have validated TAM in a wide variety of applications of information technology, and claimed that perceived usefulness and perceived ease of use increased the intention and willingness to access data through adequate informational system, such as e-commerce through the website, e-service in B2C, as well as online game [14][15][16]. An ECDIS was a computer-based navigation information system that complied with International Maritime Organization (IMO) regulations and could be used as an alternative to paper nautical charts. Then, applying TAM to the manipulation of ECDIS, authors would like to infer that shipmate's concepts of both perceived usefulness and perceived ease of use on using ECDIS would affect their behavioral intention and attitude. And further, previous researches also discussed and provided evidences that perceived ease of use indicated direct relationship on perceived usefulness [17][18][19]. Accordingly, perceived ease of use on ECDIS would encourage shipmate use it to promote efficacy. Therefore, another three hypotheses were posited:

Hypothesis H3: Perceived usefulness on ECDIS had significant positive impact on individual attitude toward using ECDIS.

Hypothesis H4: Perceived ease of use on ECDIS had significant positive impact on individual attitude toward using ECDIS.

Hypothesis H5: Perceived ease of use on ECDIS had significant positive impact on individual perceived usefulness on ECDIS.

Moreover, previous study also showed that, in TAM, both perceived usefulness and attitude toward using indicated direct relationship on behavioral intention [3]. Referring to such description and observing shipmate's training, as well as related practical experience on ship's bridge, it was found that the attitude toward using ECDIS and the perceived usefulness on this system had relationship with the behavioral intention. Then, the final two hypotheses were proposed:

Hypothesis H6: Shipmate's attitude toward using ECDIS had significant positive impact on shipmate's behavioral intention.

Hypothesis H7: Perceived usefulness on ECDIS had significant positive impact on shipmate's behavioral intention.

3.2 Samples and data collection

For testing these hypotheses, a convenience sample of 144 participants was recruited from the department of navigation at the university in southern Taiwan. The participants were divided into two distinct parts by their practical navigation experience. 64 of them were marine college students without practical navigation experience, the mean age of these students was 20, and fifty six of them were male. Then, other 80 participants were experienced shipmates, their mean age was 24, and forty seven of them were male. Shipmates' data collection carried out while they joined a short-term training on vacation. Such division would be helpful to identify how the perceived navigational risk influenced perception of technology acceptance on ECDIS. Survey was administered in class, and for insuring that the programmed questionnaire worked as intended, a pretest of the questionnaire on a convenience sample of 17 undergraduate students conducted prior to fielding the full-scale survey, that

was used to assess its logical consistency, ease of understanding, sequence of items and contextual relevance. It led to several minor modifications of the wording and the item sequence.

3.3 Model and data analysis

According to the hypotheses mentioned above, five variables of construct appeared to comprise this research model. And for measuring the variables of construct, the questionnaire consisted of 25 items, which were designed to ask individuals to agree or disagree with statements using a Likert's scale ranged from 1 = "strongly disagree", through 3 = "neutral", to 5 = "strongly agree". In this questionnaire, the items used to measure perceived usefulness, perceived ease of use, attitude toward using, and behavioral intention to use were adapted from Davis's research (1989). And the items used to measure perceived navigational risk were taken from Weintrit and Staawicki's study [1].

Perceived navigational risk (PNR) would discourage shipmates from transacting and relying on ECDIS. Based upon the work of previous research [1], three items were used to measure the level of PNR of the participants: (v1) human error, (v2) external barrier, (v3) internal obstacle. And perceived ease of use (EOU) referred to the degree to which a person believed that using a particular system would be free of effort. The measurements of EOU construct stressed on how easy and simple participants felt ECDIS. Based upon Davis's research in TAM [3][10][17], six questionnaire items were adopted to indicate the level of perceived ease of use: (v4) operability, (v5) simplicity, (v6) mental effort, (v7) understandability, (V8) cumulative effort, (V9) cognitive valuation. Perceived usefulness (U) referred to the degree to which a person believed that using a particular system, such as ECDIS, would enhance his/her job performance. For measuring U, seven items were adopted from prior studies in TAM [3][10][17]: (v10) quality improvement, (v11) controllability, (v12) time to accomplish task, (v13) supporting critical aspects of job, (v14) productivity, (v15) performance improvement, and (v16) diversity at work. Moreover, attitude toward using indicated a psychological tendency that was expressed by evaluating a particular system with some degree of favor or disfavor [20]. In this research, students' attitude toward using ECDIS (ATT) would reveal their perception to this system. Based on prior research about measuring the construct of ATT, four items were used in this questionnaire to survey participants' attitude toward using ECDIS [20]: (v17) pleasantness, (v18) goodness, (v19) value, (v20) enjoyment. Then, behavioral intention (BI) reflected the extent to which person purposed to use a particular system, such as ECDIS on the bridge of a ship. According to the literature about the measurement of the construct of BI [20][21], five questions were used to assess participants' behavioral intention on ECDIS: (v21) expectance, (v22) desirability, (v23) comparative advantage, (v24) personal opinion, and (v25) whole evaluation.

In addition, the structure equation modeling (SEM) was used as a main tool in the following measuring procedure. But before SEM conducting, the factor loading of questionnaire items were evaluated and exhibited in Table 1. It was found that all the score of factor loading ranged from 0.53 to 0.92, well above the common acceptance levels of 0.50 [22]. And the KMO test of constructs ranged from 0.894 to 0.613, greater than recommended accepting values 0.50 [23] (Table 1).

Table 1. KMO value of constructs of junior shipmates and non-experienced students

	KMO value (Kaiser-Meyer-Olkin measure)	
	Junior shipmates	Non-experienced students
Perceived navigational risk	.674	.739
Perceived usefulness	.894	.796
Perceived ease of use	.838	.778
Attitude toward using ECDIS	.837	.814
Behavioral intention	.850	.613

3.4 Reliability and validity

The adequacy of the measurement model was evaluated on the criteria of reliability, convergent validity, and disconfirmation validity. Reliability was the extent to which varying approaches to construct measurement yield the same results [24] and was examined using the composite reliability values. As listed in Table 2 and Table 3, all of these values were greater than 0.8, well above the common acceptance levels of 0.60 [25]. And convergent validity was evaluated for the measurement scales by average variance extracted (AVE), that should exceed the variance due to measurement error for that construct (i.e. AVE should exceed 0.50). [26]. In addition,

discriminant validity was used to assess the extent to which a concept and its indicators differed from another concept and its indicators [27]. Discriminant validity was evaluated using the criteria recommended by Fornell and Larcker [26] : the square root of the AVE should exceed the correlation shared between the construct and other constructs in the model. In this research, Table 2 and Table 3 showed convergent validity and discrimant validity. It was found that the convergent validity and discriminant validity on BI in Table 2 were a little shade below the desired threshold value (AVE=0.43, $AVE^{1/2}$=0.66). However, according to prior study, low validity coefficient didn't necessarily mean that the measuring instrument and/or criterion were invalid [28], and same measuring instrument in Table 3 showed high validity coefficient. Therefore, the result on BI in Table 2 was still valid for further analysis.

Table 2. Reliability, validity, and correlation analysis for non-experienced students

	CR	AVE	$AVE^{1/2}$	PNR	U	EOU	ATT	BI
PNR	0.88	0.71	0.84	1				
U	0.95	0.71	0.84	-.462**	1			
EOU	0.89	0.60	0.76	-.480**	.477**	1		
ATT	0.91	0.71	0.84	-.550**	.567**	.400**	1	
BI	0.80	0.43	0.66	-.599**	.726**	.347**	.618**	1

**. Correlation is significant at the 0.01 level (2-tailed).
Legend: PNR= Perceived navigational risk, EOU= Perceived ease of use, U= Perceived usefulness, ATT= Attitude toward using ECDIS, BI= Behavioral intention.
1. Composite reliability (CR) $=(\sum Li)^2/(\sum(Li)^2 + \sum Var(Ei))$
2. Average variance extracted (AVE) $=\sum Li^2/(\sum Li^2 + \sum Var(Ei))$

Table 3. Reliability, validity, and correlation analysis for junior shipmates.

	CR	AVE	$AVE^{1/2}$	PNR	U	EOU	ATT	BI
PNR	0.84	0.64	0.80	1				
U	0.90	0.60	0.77	-.241*	1			
EOU	0.94	0.71	0.84	-.190	.438**	1		
ATT	0.93	0.77	0.88	-.162	.593**	.532**	1	
BI	0.91	0.68	0.82	-.268*	.621**	.466**	.682**	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
Legend: PNR= Perceived navigational risk, EOU= Perceived ease of use, U= Perceived usefulness, ATT= Attitude toward using ECDIS, BI= Behavioral intention.

4 Result and final models

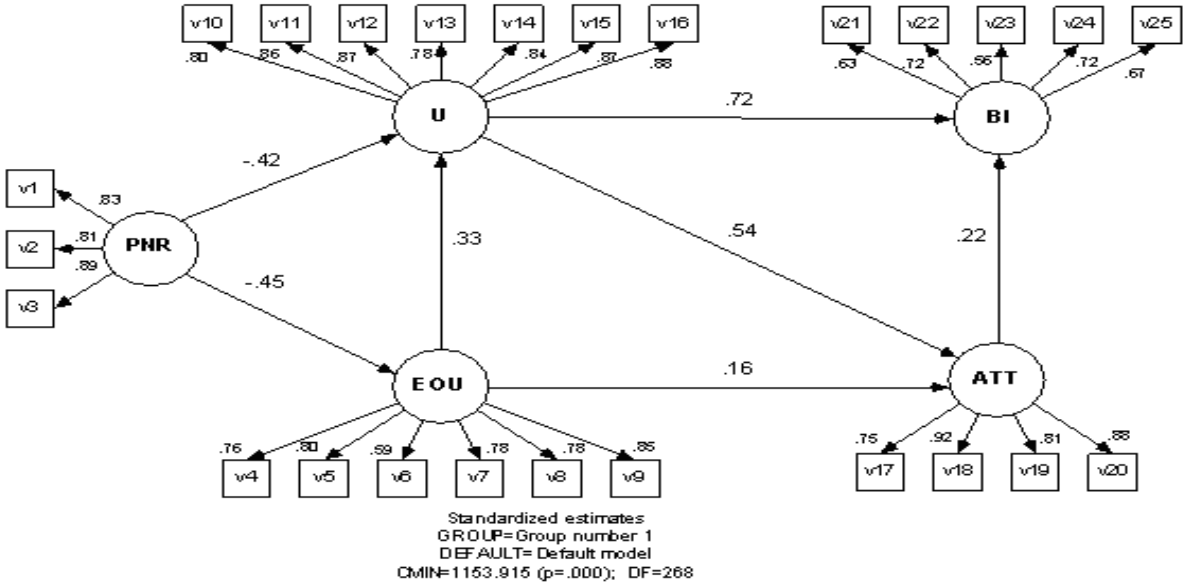
The goodness of fit of a statistical model described how well it fitted a set of observations. Measures of goodness of fit typically summarized the discrepancy between observed values and the values expected under the model in question. In this study, the type of tests for each of the measures and the corresponding results for the developed models, as well as the relevant fit statistics were presented in Table 4. Research showed that both of these two research models were adequate fit to the data. The final model of students without practical experience on board indicated that Chi-square value x^2=1153.915, p<.001, RMSEA=.082, CMIN/DF=4.306, CFI=.889. And the model of junior shipmates, as shown in Table 4, revealed that the Chi-square value x^2=474.730, p<.001, RMSEA=.079, CMIN/DF=1.771, CFI=.902 (Table 4). Although several fit indices on both models were a shade below the desired threshold value, according to commonly cited criteria for evaluating structural models [29], these two models were moderately good fit.

Model for the students without practical experience on board indicated (Fig. 1) that perceived navigational risk (PNR) had direct negative effect on perceived ease of use (EOU) (β=-0.45, p=.001<.05) and perceived usefulness (U) (β=-0.42, p=.002<.05). Therefore, when non-experienced students' perceived navigational risk scored high, the scores of perceived usefulness and perceived ease of use were lower. In addition, perceived ease of use had direct positive effect on perceived usefulness (β=0.33, p=.012<.05), it meant that when perceived ease of use scores were high, perceived usefulness scores were high also. Further, although non-experienced

students' perceived ease of use showed an insignificant direct positive effect on attitude toward using ECDIS (ATT) (β= 0.16, p=.157>.05), their perceived usefulness had direct positive effect on attitude toward using ECDIS (β=0.54, p=.000<.001), that indicated when perceived usefulness scores were high, attitude toward using ECDIS were also high. Moreover, both perceived usefulness and attitude toward using ECDIS had significant direct positive effect on behavioral intention (BI) (β=0.72, p=.000<.001, and β=0.22, p=.001<.005). It revealed that when perceived usefulness and attitude toward using ECDIS got high scores, behavioral intention scores were also high. Finally, SEM showed that, while including indirect effect, perceived navigational risk had negative total casual effect on both attitude toward using ECDIS (β=-0.30, p=.000<.001) and behavioral intention (β=-0.28, p=.000<.001) respectively.

Table 4. Fit indices for junior shipmates and non-experienced students

Fit indices	Junior shipmates	Non-experenced students	Recommended value
X^2	474.730 (p=.000)	1153.915 (p=.000)	
X^2/df	1.771	4.306	< 5 (Wheaton et al., 1977)
RMR	.050	.074	< .10 (Cole D. A., 1987)
RMSEA	.079	.082	< .08 (Gefen et al. 2000)
AGFI	.903	.899	> .90 (Hair et al., 1998)
NFI	.910	.858	> .90 (Hayduk, 1987; Bentler and Bonett, 1980)
CFI	.902	.889	> .90 (Hayduk, 1987; Bentler and Bonett 1980)

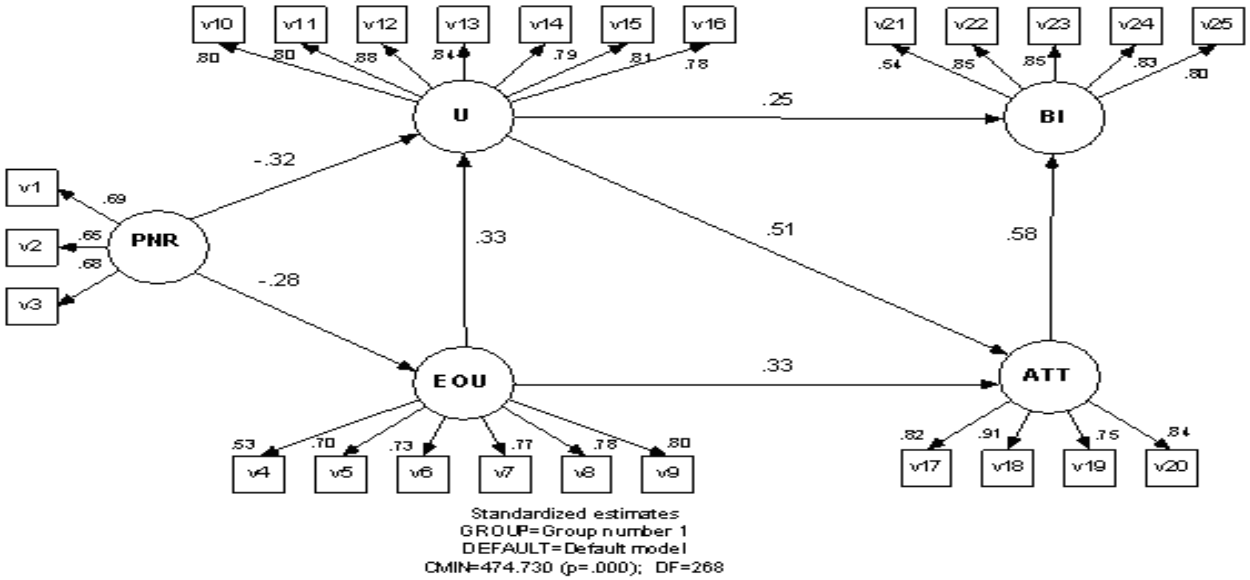


Legend: PNR= Perceived navigational risk, EOU= Perceived ease of use, U= Perceived usefulness, ATT= Attitude toward using ECDIS, BI= Behavioral intention.

Fig. 1. Model for non experienced students

Fig. 2 presented the model for junior shipmates, it revealed that perceived navigational risk had significant direct negative effect on both perceived ease of use (β=-0.28, p=.047<.05) and perceived usefulness (β=-0.32, p=.024<.05) respectively, indicating that when perceived navigational risk scored higher, the scores of both perceived ease of use and perceived usefulness became lower. Meanwhile, perceived ease of use had direct positive effect on perceived usefulness, β=0.33, p=.009<.05, it meant that when perceived ease of use scored high, perceived usefulness scores were high also. Moreover, both perceived ease of use and perceived usefulness showed direct positive effect on attitude toward using ECDIS, the former (β=0.33, p=.003<.05) and the latter (β=.51, p=.000<.001). It

indicated that when the scores of both perceived ease of use and perceived usefulness were high, attitude toward using ECDIS scored high also. In addition, both perceived usefulness and attitude toward using ECDIS had a direct positive effect on behavioral intention (β=0.25, p=.048<.05 and β=0.58, p=.000<.001). Finally, analysis also revealed that, while including indirect effect, perceived navigational risk had significant negative total casual effects on both attitude toward using ECDIS (β=-0.38, p=.000<.001) and BI (β=-0.49, p=.000<.001) respectively.



Legend: PNR= Perceived navigational risk, EOU= Perceived ease of use, U= Perceived usefulness, ATT= Attitude toward using ECDIS, BI= Behavioral intention.

Fig. 2. Model for junior shipmates

5 Discussion and implication

The goal of this study was to empirically extend current understanding about how the perceived navigational risk affected technology acceptance for participants with/without practical experience on board, and TAM was the main theory applied on this research. Authors in this paper postulated that ECDIS usage was determined by behavioral intention which was viewed as being jointly determined by user's attitude toward using ECDIS and perceived usefulness. According to the TAM [3], the relationship between attitude and behavioral intention implied that people formed intentions to perform behaviors toward which they had positive affect. And the relationship between perceived usefulness and behavioral intention was based the idea that people formed intentions toward behaviors they believed would increase their job performance. In this research, both models for different participants showed that the attitude toward using ECDIS and perceived usefulness had significant positive effect on behavioral intention. But analysis in SEM revealed some differences: For non-practical experienced students, perceived usefulness on ECDIS formed more intentions toward behavior (β=0.72) than attitude did (β=0.22); Then on the contrary, for those shipmates, attitude presented more intentions (β=0.58) to perform behavior than perceived usefulness did (β=0.25).

Further, according to TAM, attitude was jointly determined by perceived usefulness and perceived ease of use. As discussed on prior study [3], TAM posited that perceived usefulness had a direct effect on attitude over and above behavioral intention, Davis et al. illustrated that positively valued outcomes often increased one's affect toward the means to achieving those outcomes [3]. And previous research also contained empirical evidence consistent with a link between attitude and perceived ease of use [10][30]. In addition, Bandura proposed that the easier a system was to interact with, the greater should be the user's sense of efficacy [31]. In this study, the model for shipmates showed that both perceived usefulness (β=0.51) and perceived ease of use (β=0.33) had significant direct effect on the attitude toward using ECDIS. But for the non-

practical experienced students, although perceived usefulness indicated significant direct effect on the attitude toward using ECDIS, the causal relationship between perceived ease of use and the attitude toward using ECDIS was insignificant.

In addition, improvements in perceived ease of use, as described in TAM, might also be instrumental and contributing to increase performance. Effort saved due to improved perceived ease of use might be redeployed, enabling a person to accomplish more work for the same effort [3]. To a certain extent that increased perceived ease of use contributed to improved performance. Accordingly, perceived usefulness and perceived ease of use were viewed as distinct but related constructs, empirical associations between variables similar to perceived usefulness and perceived ease of use have been observed in prior research [32]. Such associations were identified as well in this study. It found that perceived ease of use had significant direct effect on perceived usefulness on both two models.

Moreover, TAM also posited that both perceived usefulness and perceived ease of use could be affected be external variables. Several investigators have found that the characteristics of a system or the environment involved had a direct effect on U as well as perceived ease of use. In this research, the potential navigational risk from human error, external interference outside of the ECDIS, and internal obstacle of ECDIS were included in the construct of perceived navigational risk. These items

and error. Although this research showed that perceived navigational risk had negative influence on perceived usefulness and ease of use, it is still a crucial trend for shipmates to apply information technology and related computerized system to promoting their efficacy and accuracy on navigation. Therefore, for efficient pushing the transition from conventional tools to modern navigational information system, besides manufacturer's promoting the accuracy of ECDIS and standardizing ECDIS update procedures, this study provides worthy reference for training center and marine college to improve the training course by inheriting experience and expertise from excellent master or senior shipmates, and enhancing the teaching of information literacy as well as navigation-related information technology.

However, there were some limitations in this study. Firstly, the respondents were college students and junior shipmates, their limited experience could not fully recognize all the potential risk. Secondly, the perceived navigational risk on ECDIS might be affected due to participants' insufficient proficiency on manipulating this integrated system, but such were measured to present perceived navigational risk's influence on perceived usefulness and perceived ease of use. This study showed that no matter which model, perceived navigational risk presented significant negative effort on perceived usefulness and perceived ease of use. To a navigational information system such as ECDIS, any fault or defect of this system probably threatened ship's safety, or even caused serious damage. Therefore, any doubtfulness or suspicion about the usability, accuracy, or validity on ECDIS would decrease user's perceivability on ECDIS's usefulness and ease of use. Even so, difference still existed between these two models: it showed that, for experienced shipmates, perceived navigational risk had less negative effect on perceived ease of use and perceived ease of use while compared with non-experienced students. Obviously, the experienced shipmates were less affected by the perceived navigational risk.

Navigating with ECDIS is fundamentally different from navigating with paper charts, the former is a system which integrates several different functions into one computerized system, and is designed to improve the accuracy and efficacy of navigation, as well as ship's safety. Unfortunately, the nightmare-like navigational risk has serious negative influence on shipmate's confidence and reliability on ECDIS, even they often use conventional tools, such as sextant or radar, to verify ECDIS's normal condition or correct its inaccuracy influence was not measured in this study. And third, the well-trained senior seafarers might have quite different comprehension on the relationships between potential navigational risk and technology acceptance, but unfortunately, they were not included in this research.

6 Conclusion

The official proposal to develop e-navigation was submitted to the Maritime Safety Committee of IMO in December 2005 as a strategic vision for the utilization of existing and new navigational tools, in particular electronic ones, in a holistic and systematic manner. But while the authority and maritime transport community focused on integrating and developing modern technological instrument for promoting the efficacy and effectiveness on navigation, users' subjective and psychological predispositions should not be ignored. The objective of this study was to discover how the perceived navigational risk affected the technology acceptance and its differences. The results not only verified the most parts of hypotheses proposed in this research and released that the user's experience would modify

the influences of perceived navigational risk on TAM model, but also provided important references for manufacturers and marine college to adjust their products, or enhance the training course in order to upgrade seafarers' information literacy, as well as the ability of manipulating modern navigational information system.

References:

[1] Weintrit, A., & Stawicki, K., Operational requirements for electronic chart display and information systems (ECDIS) – risk of overreliance on ECDIS, *Transport Problems*, (2), 3, 2008, pp.75-82.

[2] Bowditch, N., *American practical navigator*. Bicentennial Edition, National Imagery and Mapping Agency, 2002, pp.219-221.

[3] Davis, F. D., Bagozzi, R. P., & Warshaw, P. R., User acceptance of computer technology: a comparison of two theoretical models, *Management Science*,1989, (35), 8, pp.982-1003.

[4] IMO Resolutions A.817 (19), MSC.64 (67) and MSC.86 (70). Performance standards for electronic chart display and information systems (ECDIS). (amended March 1999). Available from *http://www.imo.org/OurWork/Safety/Navigation/Pages/Charts.aspx*.

[5] Treat, A., Risk Assessment Method for ECDIS, Hydro International, (7), 2, 2003. Available from *http://www.hydro-international.com/issues/articles/id95-Risk_Assessment_Method _for_ ECDIS.html* (last accessed May 2011).

[6] Cunningham, S. M., The major dimensions of perceived risk. In D. F. Cox (Ed), Risk taking and Information Handling in Consumer Behavior. Graduate School of Business Administration, *Harvard University Press*: Boston. 1967, pp.82-108.

[7] Harland, C., Brenchley, R., & Walker, H., Risk in Supply Networks. *Journal of Purchasing & Supply Management*, 9, 2003, pp.51-62.

[8] Bauer, R. A., Consumer Behavior as Risk Taking in Dynamic Marketing for a Changing World. Chicago: *American Marketing Association*, 1960, pp.389-398.

[9] Cox & Donald, F., Risk handling in Consumer Behavior. Boston, MA: *Harvard University Press*, 1967.

[10] Davis, F. D., Perceived usefulness, perceived ease of use, and use acceptance of information technology, *MIS Quarterly*, 1989, (13), 3, pp.319-340.

[11] Agarwal, R., & Prasad, J., Are individual differences germane to the acceptance of new information technologies? *Decision Science*, 1999, (30), 2, pp.361-391.

[12] Mallette, H., & Fisher, R., The effects of non-volitional use on perceptions and intention of end user. *28th Annual Atlantic Schools of Business Conference*, Wolfville, Nova Scotia, 1998.

[13] Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D., User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27, 2003, pp.425-478.

[14] Jarvenpaa, S. L., Tractinsky, N. & Vitale, M., Consumer trust in an internet store. *Information Technology and Management*, (1), 12, 2000, pp.45-71.

[15] Vijayasarathy, L. R., & Jones, J. M., Print and internet catalog shopping: assessing attitudes and intentions, *Internet Researsch*, 10, (3), 2000, 99.191-202.

[16] Liu, X., & Wei, K., An empirical study of product differences in consumers' e-commerce adoption behavior. *Electronic Commerce Research and Applications*, (2), 5, 2003, pp.229-239.

[17] Davis, F. D., User acceptance of information technology: System characteristics, user perceptions and behavioral impacts. *International Journal of Man-Machine Studies*, 1993, (38), 3, pp.475-487.

[18] Hsu, C. L. & Lu, H. P., Why do people play on-line games? An extended TAM with social influences and flow experience. *Information & Management*, (41), 7, 2004, pp.853-868.

[19] Yu, J., Ha, I., Choi, M, & Rho, J.,Extending the TAM for a t-commerce. *Information & Management*, (42), 7, 2005, pp.965-976.

[20] Fishbein, M., & Ajzen, I., Belief, *Attitude, Intention, and Behavior : An introduction to theory and research. Reading*, Mass; Don Mills, Ontario: Addison-Wesley Pub. Co., 1975.

[21] Eagly, A. H., & Chaiken, S., *The psychology of attitudes*. Fort Worth: Harcourt Brace Jovanovich College Publishers, 1993.

[22] Hair, J. F., Anderson, R. E., Tatham, R. L. & Black, W. C., *Multivariate Data Analysis*, Prentice-Hall International, Inc., 1998, 5th Edition, Chapter 11.

[23] Lin, C. S., Wu, S., & Tsai, R. J., Integrating perceived playfulness into expectation-confirmation model for web portal context.

Information & management, 42, 2005, pp.683–693.

[24] Campbell, D. T., & Fiske, D. W., Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, 1959, (56), 2, pp.81-105.

[25] Bagozzi, R., & Yi, Y., On the evaluation of structural equation models, *Journal of the Academic of Marketing Science*, 1998, No 16, pp.74-94.

[26] Fornell, C., & Larcker, D.F., Evaluating structural equation models with unobservables and measurement error, *Journal of Marketing Research*, 1981, (18), 1, pp.39-50.

[27] Bagozzi, R., Yi, Y., & Phillips, L., Assessing construct validity inorganizational research, *Administrative Science Quarterly*, 1991, (36), 3, pp.421-458.

[28] Edward, G., Carmines, Richard A. and Zeller, *Reliability And Validity Assessment*, Sage Publications, 1979

[29] Hu, L. T., & Bentler, P. M., Fit indices in covariance structure modeling: sensitivity to underparameterized model misspecification, *Psychological Methods*, 3, 1998, pp.424-453.

[30] Carroll, J. M., & Thomas, J. C., Fun, *SIGCHI Bulletin*, 1988, 19, pp.21-24.

[31] Bandura, Self-Efficacy Mechanism in Human Agency. *American Psychologist*, 1982, 37, pp.122-147.

[32] Barrett, G. V., Thornton, C.L., & Cabe, P.A., Human factors evaluation of a computer based storage and retrieval system, *Human Factors*, 1968, (10), 4, pp.431-436.