

For the exploration of the answer to this research question, the researchers targeted to obtain students' views on the factors affecting their multimedia learning for this research and considered the task-technology fit model and technology acceptance model as they provide the key elements that influence the students' attention to adopt multimedia learning.

This exploration is significant in the sense that understanding the factors that influence students' acceptance of multimedia learning technology can help to set guidelines for the education management and administrators on how multimedia learning can be implemented. Especially, with the advancement of Internet technology and availability of Internet access through wireless fidelity or mobile broadband technologies, online or blended learning mode has been implemented. Multimedia learning can be incorporated into online or blended learning. The exploration in this study can also help the education management and administrators to incorporate multimedia learning into online or blended learning environments.

3. New Technology Acceptance Model for the Study

Among the models related to a fit between task and technology as well as technology acceptance, Task-Technology Fit (TTF) by Goodhue and Thompson [6], Technology Acceptance Model (TAM) by Davis [7] and its extension Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh, Morris, Davis, and Davis [8] were commonly used in literature. TTF concerns about whether a technology fits a task. If the technology fits the task to be performed by an individual, that individual will actually use the technology and that usage and fitness affect the individual's task performance. TTF is visualized in Figure 1 in which an arrow indicates influence or determination.

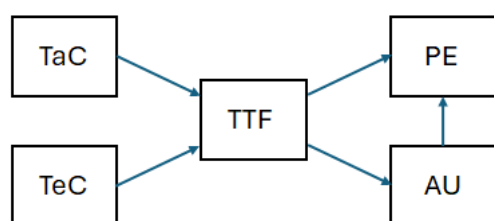


Figure 1. Task-Technology Fit by Goodhue and Thompson [6]

Task characteristics (TaC) and **technology characteristics (TeC)** determine the **task-technology fit (TTF)** construct. TTF construct is the degree to which the technology characteristics fit the task characteristics. The TTF construct in turn influences the individual's **actual usage (AU)** of the

technology and that individual's task **performance expectancy (PE)**. AU also affects PE.

If an individual intends to use a technology, that individual will actually use that technology. In TAM, an individual's **behavioral intention (BI)** to use a technology is a prerequisite for that individual's **actual usage (AU)** of the technology in TAM, as shown by the arrow pointing from BI to AU in Figure 2. The individual's BI is in turn influenced by that individual's **perceived usefulness (PU)**, which is the extent to which that individual believes using the technology can enhance job performance, and **perceived ease of use (PEOU)**, which is how easy that individual regards when using that technology. In other words, TAM theorizes that if a technology is easy to use and makes the person who uses the technology perform well, it is more likely that the person intends to use the technology, eventually, will actually use that technology.

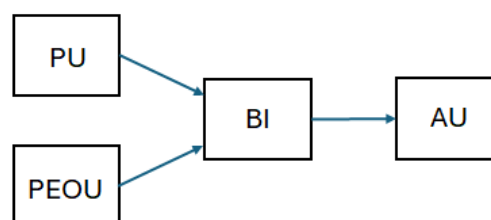


Figure 2. Technology Acceptance Model by Davis [7]

UTAUT was formulated through a review and synthesis of some other models related to technology acceptance including TAM. UTAUT contains moderating (or, indirect) effects (i.e., gender, age, experience and voluntariness of use), but they are not examined in this study as the researchers intend to obtain the findings in this study that can be applicable to any gender and expect there is not much difference in age, experience and voluntariness of use as the participating students with similar ages have similar experience in using multimedia technology which are not on a voluntary basis.

In UTAUT, **performance expectancy (PE)** is similar to PU in TAM and **effort expectancy (EE)** is similar to PEOU in TAM. All these PE, EE, BI and AU are derived from TAM. As theorized by UTAUT used in this study in Figure 3, AU is determined by BI and **facilitating conditions (FC)** such as required software and hardware, technical support, and training. BI is in turn determined by PE, EE, and **social influence (SI)** which is the extent to which the users perceive that the people around them such as parents, teachers, supervisors, classmates, friends, and relatives expect that they should use the technology. Figure 3 shows UTAUT with moderating effects left out.

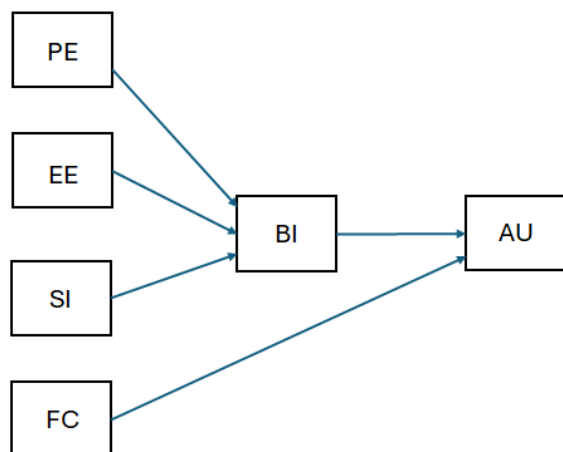


Figure 3. Unified Theory of Acceptance and Use of Technology by Venkatesh, Morris, Davis, and Davis [8]

Having considered the model by Goodhue and Thompson [6] which examined the fit of technology to a user's task, TeC was left out in this study as the multimedia learning technology characteristics involve students' viewing of the multimedia materials and that characteristics would not affect their competence in using the multimedia technology. In this regard, TaC and TTF constructs in [6] can be combined in this study and collectively called **multimedia facilitation (MF)** which means facilitation by the characteristics of the multimedia learning materials. Having reviewed TAM by Davis [7] and its extensions for learning in the literature, the researchers found a relevant model by Park, Nam, and Cha [9] in which **relevance for major (MR)** construct influencing PE. MR is a student's belief that the student's major of study is related to multimedia technology such as multimedia design, computer science and information management system. Having all these issues in mind, the researchers combined some relevant UTAUT constructs, MF, and MR and came up with the model shown in Figure 4.

In Figure 4, **performance expectancy (PE)** is the degree of the student's belief in using the multimedia learning technology can enhance learning, **effort expectancy (EE)** is the degree of the student's perception of the digital literacy, self-efficacy and ease of use of the multimedia learning technology, **social influence (SI)** is the extent to which the student perceives the influence from the social presence, that is, the student's perception that the people around the student such as classmates, teachers, friends and parents expect that student should perform the technology usage behavior, and **behavioral intention (BI)** is the student's intention to use multimedia learning technology. This model illustrates that MR and MF influence PE; in turn, PE and the other two constructs EE and SI influence BI.

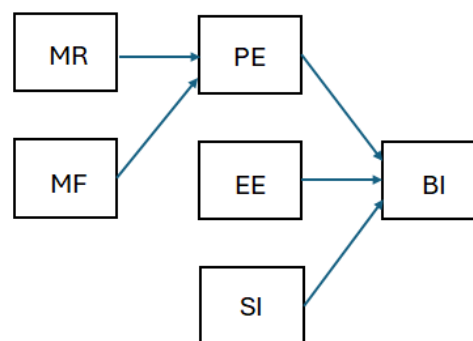


Figure 4. New technology acceptance model for this study

4. Literature Review

To know what have been found about the factors influencing students' acceptance of multimedia learning in literature, literature review was conducted. For this review, the inclusion criteria were first set. The inclusion criteria set for literature search included the empirical studies reporting or explaining the relationship (e.g., correlation and regression) between any of the independent variables (e.g., MR and MF) and the dependent variables (e.g., PE) for the acceptance of multimedia learning technology. Scopus was mainly used for literature search as it covers different areas of study more comprehensively [10]. Scopus also contains a friendly user interface.

To the best of the researchers' knowledge at the time of writing this article, there were no studies reporting or explaining why any of MR and MF influence PE in Figure 4 found in the literature search. The relevant studies found in the literature include the studies by Lee and Ryu [11], Mozhenko, Donchyk, Yushchenko, Suchkov, and Yelenskyi [12], Saadé, Nebebe, and Tan [13], and Alsaffar, Alfayly, and Ali [14]. [11]-[13] examined the effects of PE and EE on BI indirectly while [14] investigated the effects of PE, EE, and SI on BI indirectly. Unlike their studies that were based on Davis' TAM [7], this study adopted the outperforming UTAUT [8] which was formulated by reviewing and consolidating the constructs in [7] and its extensions.

5. Methodology

This study was conducted with approval at the case higher education institution which offers a large variety of associate degree and higher diploma programs (e.g., Associate of Arts, Associate in Language and Digital Communication, Associate in Engineering, Associate in Applied Social Sciences, Associate in Business, Higher Diploma in Aircraft Services Engineering, and Higher Diploma in Social Work) for high school (or, secondary school) graduates in Hong Kong. In the semesters 1 and 2 of the academic years from 2016 to 2022, multimedia

learning on the insertion sort method in Java, as presented in [15], was given to the registered Associate in Information Technology students at the case higher education institution.

Insertion sort method is one of sorting methods used to arrange things in order which can be ascending or descending order. Examples of sorting include sorting names or identity numbers in order for searching a particular person and sorting publication dates into descending chronological order for easy search for the recent publications. The following is an insertion scenario for explaining how insertion sort works:

For example, to insert the integer 7 into an array of ascending integers {2, 4, 8, 9}, then:

1. compare the new integer 7 with the largest integer 9 placed at the rightmost position of the sorted array {2, 4, 8, 9}.
2. 7 is less than 9, then shift 9 to the right and the sorted array becomes {2, 4, 8, , 9}.
3. compare the new integer 7 with 8.
4. 7 is less than 8, shift 8 to the right and the sorted array becomes {2, 4, , 8, 9}.
5. compare the new integer 7 with 4.
6. 7 is not less than 4, 4 is not shifted to the right.
7. insert 7 into the space between 4 and 8, then the sorted array becomes the list of sorted integers in ascending order {2, 4, 7, 8, 9}.

Insertion sort starts with inserting the second integer into the first integer at the leftmost position of a list of ascending integers, then the first two integers become a sorted list of ascending integers. After that, the insertion sort inserts the third integer into the sorted list. After that insertion, the first three integers become a sorted list of ascending integers. The insertion sort keeps inserting in this way until the rightmost integer is inserted into the sorted list. The result is the sorted list of ascending integers. For example, to sort the unsorted list of integers {7, 3, 2, 6, 4} using insertion sort, use the following:

1. insert the second integer 3 into the first integer 7, then the list becomes {3, 7, 2, 6, 4}.
2. insert the third integer 2 into the sorted list part {3, 7} (the first two integers in the list). Then, the list becomes {2, 3, 7, 6, 4}.
3. insert the fourth integer 6 into the sorted part {2, 3, 7}. The list becomes {2, 3, 6, 7, 4}.
4. insert the last integer 4 into the sorted part {2, 3, 6, 7}. The list becomes a sorted list of ascending integers {2, 3, 4, 6, 7}.

This insertion scenario was adopted to build the multimedia learning materials in Microsoft PowerPoint format, as presented in Figure 5.

The figure shows two slides from a multimedia presentation. Each slide features a table representing an array `a` with indices `a[0]` through `a[4]` and values 7, 3, 2, 6, 4. Below the table is a code snippet for building a sorted array `a[0:i]`.

Top Slide: The code snippet is as follows:

```

• // build the sorted array a[0:i]
• for (int i = 1; i < a.length; i++) {
•     int temp = a[i];
•     int j;
•     // insert a[i] into the sorted array a[0:i-1]
•     for (j = i; j > 0 && temp < a[j-1]; j--)
•         a[j] = a[j-1];
•     a[j] = temp;
• }

```

Bottom Slide: The code snippet is similar, but with a red arrow pointing to the line `int temp = a[i];`.

Figure 5. Sequence of multimedia slides explaining an insertion sort method in Java

5.1. Multimedia Learning

The animated Microsoft PowerPoint slides, as shown in Figure 5, were used in the case lesson. In the case lesson, students learnt how to develop a Java program using insertion sort method to arrange given integers in ascending order. In the case lesson, the multimedia learning materials contained animated sequence of graphics with narration in Microsoft PowerPoint format. Figure 5 displays a sequence of some Microsoft PowerPoint slides explaining the insertion sort method in Java. The narration for the upper slide in Figure 5 is: *At the first outer for-loop, the variable i is set to 1, then it checks the outer for-loop condition, $i < a.length$, by comparing it with $a.length$ which returns 5, the size of the array as there are 5 integers in the array. The condition, $1 < 5$, is true.* The narration for the lower (i.e., following) slide in Figure 5 is: *Then the variable temp is set to $a[1]$ which is 3, $temp = 3$.* To avoid the confounding effect by guidance from the instructors or other peer students, the participating students view the multimedia learning materials by themselves without any guidance in the lesson.

5.2. Data Collection

To collect data on whether and how the students accept using the multimedia materials for learning insertion sort in Java, convenience sampling was used – those registered students were invited to participate in a survey. When inviting the students to participate in the survey, the research purpose, scope, and procedure were explained to the students.

The students' participation in a survey was voluntary with implied consent [16, p. 46] which indicates that the students agree to participate in the survey when they complete a questionnaire. The questionnaire was posted online and designed with reference to the measuring items validated in [7]-[9]. That online questionnaire was designed to collect the students' perceptions of the constructs in Figure 1. A 5-point Likert scale with 5 = strongly agree to 1 = strongly disagree was used to measure the constructs. Table 1 shows the measuring items for MR and MF on the online questionnaire.

Table 1. MR and MF measuring items on the online questionnaire

<i>Construct</i>	<i>Measuring Item</i>	<i>Measuring Statement</i>
MR	MR1	Using the multimedia materials for programming learning is relevant to my study area.
	MR2	Using the multimedia materials for programming learning can help me understand the courses in my study area.
MF	MF1	The multimedia materials help me understand the subject.
	MF2	Learning with the use of the multimedia materials is a good way to make me understand programming.
	MF3	Using the multimedia materials to learn can enhance my understanding of the subject.
	MF4	Learning with the use of the multimedia materials can help me to apply my programming skills.

Table 2 shows the measuring items related to UTAUT in Figure 1 on the online questionnaire. 166 students experienced multimedia learning through the case lesson participated in this survey by completing the online questionnaire.

All the constructs contain at least two similar items with corresponding similar statements which should yield similar Likert's scores. This similarity was tested with the internal consistency reliability evaluated with Cronbach's coefficient alpha [17].

Table 2. UTAUT measuring items on the online questionnaire

<i>Construct</i>	<i>Measuring Item</i>	<i>Measuring Statement</i>
PE	PE1	I would find the multimedia materials useful for my programming learning.
	PE2	Using the multimedia materials enables me to learn programming more quickly.
	PE3	Using the multimedia materials enhances my programming learning.
	PE4	If I use the multimedia materials to learn, I will increase my chances of getting a better grade in my study.
EE	EE1	My interaction with the multimedia materials would be easy.
	EE2	It would be easy for me to become skillful at using the multimedia materials to learn programming.
	EE3	It easy to use the multimedia materials for learning programming.
	EE4	Learning to operate the multimedia materials for learning programming is easy for me.
SI	SI1	People who influence my behavior think that I should use the multimedia materials to learn programming.
	SI2	People who are important to me think that I should use the multimedia materials to learn programming.
	SI3	The senior management/lecturer of this educational institution has been helpful in the use of the multimedia materials to learn programming.
	SI4	In general, the organization has supported the use of the multimedia materials to learn programming.
BI	BI1	I intend to use the multimedia materials to learn programming if those multimedia materials are available in the coming semesters.
	BI2	I am willing to use the multimedia materials to learn programming if those multimedia materials are available in the coming semesters.
	BI3	I like to use the multimedia materials to learn programming if those multimedia materials are available in the coming semesters.

5.3. Analysis

Multiple regression analysis was adopted as it can explore the combined and relative effects of the

independent variables on the outcome variables in Figure 4. For multiple regression, the threshold, denoted by N , is $N \geq 50 + 8w$ where w is the number of independent variables [18]. From Figure 4, at most, three independent variables (i.e., PE, EE, and SI) on the dependent variable BI in a regression model is involved, then the threshold is $50 + 8 \times 3 = 74$. The sample size of 166 participating students is appropriate as it is larger than the threshold 74. To perform multiple regression analysis, the statistical tool Statistical Package for the Social Sciences (SPSS) version 28 was used.

6. Results

All the values of Cronbach's coefficient alphas generated by SPSS are all above 0.7, reaching the acceptable internal consistency reliability [19]. Table 3 shows the multiple regression results that explained PE. It shows the effects of MR and MF on PE. This model explained 64% of the variance in PE. The significant results, indicated by $\rho < 0.05$, show that MF was a stronger determinant with larger standardized regression coefficient 0.51.

Table 3. Regression Results Explaining PE

Independent Variable	Students (n = 166)	
	Adjusted R^2	β
	0.640	
MR		0.302
MF		0.510 **

* $\rho < 0.05$, ** $\rho < 0.01$, *** $\rho < 0.001$
 β standardized regression coefficients

Table 4 shows the multiple regression results that explained BI. It shows the effects of PE, EE, and SI on BI. This regression model explained 89.9% of the variance in BI. The significant results at $\rho < 0.05$ show that SI had stronger effect on BI.

Table 4. Regression Results Explaining BI

Independent Variable	Students (n = 166)	
	Adjusted R^2	β
	0.899	
PE		0.127 **
EE		0.113
SI		0.742 ***

* $\rho < 0.05$, ** $\rho < 0.01$, *** $\rho < 0.001$
 β standardized regression coefficients

7. Discussions and Implications

The analytical results revealed the larger effect of MF on PE and the larger effect of SI on BI. These results indicate that MF has an indirect effect via PE while SI has a direct effect on BI. The effect of MF on PE provides an implication that the design of multimedia formats is important for the students' learning performance. This result is in line with studies by Mayer [4] that different designs of

multimedia contents exhibit different students' learning enhancements. The other result of the effect of SI on BI indicates that the students' intention to use multimedia learning is influenced by the social presence such as facilitations from their classmates, teachers, friends, and parents. In this regard, to implement multimedia learning in online or hybrid learning mode, teachers, and peer classmates play an important role to facilitate multimedia learning.

However, these quantitative findings cannot help to explain how MF affects PE and how SI influences BI. Also, the quantitative findings cannot help to confirm the cause-effect relationship between MF and PE, and SI and BI. To have a better explanation and better confirmation, Creswell and Gutterman's explanatory sequential design of mixed methods [20] is proposed. In this design, the findings from a quantitative approach are used and reviewed for follow-up by a qualitative approach to obtain explanation and confirmation. Also, both the quantitative and qualitative findings can be used for triangulation.

8. Conclusion

Mayer [4] and his co-investigators conducted more than 200 experimental studies that provide empirical evidence on enhanced learning performance from multimedia learning formats. Different from the perspective of learning enhancement, the researchers in this study attempted to explore the students' acceptance of multimedia learning technology. This study is important in the sense that the students' acceptance of multimedia learning technology is a prerequisite for learning enhancement from multimedia learning.

Based on the proposed theoretical model of technology acceptance and analytical results in this study, it is found that the characteristics of the multimedia learning materials enhance the students' learning performance and therefore arouse their intention to adopt multimedia learning while the facilitations from the students' friends, classmates, teachers, and parents influence their intention to use multimedia learning.

For a better understanding of how the constructs influence the students' acceptance of multimedia learning and how multimedia learning should be implemented, a qualitative approach of in-depth interviews and content analysis can be conducted as a follow-up in future. Suggested future research direction should also include examining MR construct in a better way by inviting participants from a variety of majors of study instead of just only information technology major in this study.

9. Acknowledgement

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