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Research Paper

Factors affecting students' online learning outcomes: a case study at Amsterdam High School for the Gifted

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ABSTRACT: *Learning use the internet connection or intranet technology is growing rapidly over the traditional methods of learning and teaching. Fifteen sub-factors were identified, and then divided into four factors: Instructor, student, course content and technology. Data were collected through interviews with students using a questionnaire. This study applies the AHP method to determine the level of factors affecting student learning outcomes at Amsterdam High School for the Gifted. The results show that "Instructor" is the most important factor, following by "Student", "Course content" and "Technology".*

Keywords: *Online learning; Learning outcomes; Amsterdam High School for the Gifted*

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I. INTRODUCTION

Online learning is a technology-based teaching activity through an internet connection or an intranet technology. The explosion of science and technology has created many opportunities for online teaching. In addition, the Covid-19 pandemic has prompted educational institutions to switch from traditional learning to online teaching (Saleem et al., 2022).Deploying online teaching brings educational institutions many benefits such as sharing knowledge and skills flexibly, not being limited in time and space, saving costs and increasing interaction (Farid and Qadur, 2018).However, for online learning to be effective, educational institutions must have a good online teaching platform, and at the same time, teachers and students must be able to use technology devices (Andrel et al., 2020).

There have been a number of studies that have indicated important factors affecting students' online learning outcomes, including lecturers, students, lecture's content, technology infrastructure for teaching (Naveed et al., 2020; Das and Meredith, 2021; Merhi, 2021; Lin et al., 2021; Saleem et al., 2022). Cheawjindakarn et al. (2012) analyzed critical success factors for online distance learning in higher education. Das and Meredith (2021) employed the step-wise regression analysis to identify factors in teacher's effective transition for successful online teaching. They indicated that professional training, students' performance evaluation, cheating concerns in exam perceived by teachers, infrastructure difficulties, lack of students' technological knowhow and difficult online classroom management influenced success in online teaching.Lin et al. (2021) developed a model to explore the impact of online learning on students' attitude and behavioral intention. They found that push effects (perceived security risk, learning convenience, and service quality), pull effects (usefulness, ease of use, teacher's teaching attitude, tasktechnology fit), and mooring effects (switching cost, habit) had significantly influenced the switching intentions of users from physical course to online learning platforms.Thi Tinh Thuong Pham et al. (2021) assessed factors affecting students' online learning outcomes during the COVID-19 pandemic using the convenience sampling method via questionnaires. The Bayesian Exploratory Factor Analysis was applied to analyze the data. The results indicated that students' online learning outcomes are affected by 6 factors in the descending order, respectively, learner characteristics, perceived usefulness, course content, course design, ease of use, and faculty capacity. Saleem et al. (2022) used a stepwise linear regression and "Process Macro" to analyze the factors affecting the quality of online learning of Pakistani students during the COVID-19 pandemic. They revealed that university support, instructors' support, and

motivational factors predicted the quality of online learning. The situational factors negatively influenced the relationship of instructors' support and motivational factors and the quality of online learning. University support and the quality of online learning relationships were not moderated by situational factors.

Nowadays, the analytic hierarchy process proposed by Saaty in 1981 is a commonly used method to determine the priority of criteria, as well as the influence of factors. The AHP method was widely applied in almost all fields from economics to education and engineering. There have been a number of studies applying the AHP method to identify important factors affecting students' online learning outcomes. Naveed et al. (2020) employed the (AHP) with group decision-making (GDM) and Fuzzy AHP to evaluate the critical success factors in implementing E-learning system. Merhi (2021) applied an analytical hierachy process to evalute the critical factors that influence the implementation of data intelligence in public sectors. His analysis indicated that the project management, information systems and data, and data quality are the most important factors among the fourteen critical success factors.This study uses the AHP method to determine the level of factors affecting student learning outcomes.

II. AHP APPROACH

Saaty (1980) developed the AHP approach to solve the problems which may consist of multiple-criteria, multiple-levels, complex structure, etc. using a pairwise judgment from decision makers. The decision maker gives the judgment in a pairwise comparison using nine-point scale as given in Table 1.

Table 1. Scale measurement

Intensity of relative importance	Definition
1	Equally preferred
3	Moderately preferred
5	Essentially preferred
7	Very strongly preferred
9	Extremely preferred
2, 4, 6, 8	Intermediate importance between two adjacent judgements

The detailed AHP approach is shown as follows:

***Step 1*:** Constructing a comparison matrix between factors

$$DM = (a_{ij})_{\text{nxn}} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix}$$

where $a_{ji} = 1/a_{ij}$, for $i, j = 1,\ldots,n$ and $i \neq j$.

Step 2: Determine the geometric means (GM) of each pairwise decision. Then, the pairwise decision and subsequent priority vector (PV) are be calculated.

Step 3. Caculate the consistency ratio

The value of consistency ratio (CR) is significant to decide whether the derived a pairwise judgmental matrix is acceptable or not. Based on the CR value the matrix is accepted if the obtained CR value is less than 10%. The CR is obtained by $CR = \dfrac{CI}{RI} = \dfrac{(\lambda_{\max} - n)}{(n-1)}$

where: n is the matrix size; $\lambda_{\max} = \sum_{i,j=1}^{n} C_j.PV_i$; C_j is the sum of each vector column vectors.

The values of random index (RI) are defined by Table 2.

Table 2. Random Consistency Index.

n	RI
1	0
2	0
3	0.52
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

10	1.49

III. APPLICATION OF THE AHP APPROACH

This section applies the Saaty's AHP approach to analyze the factors affecting students' online learning outcomes. Data were collected through in-depth interviews with students at Amsterdam High School for the Gifted, Vietnam. A committee of fourstudents (D1, D2, D3 and D4) conducted the evaluation of the critical factors affecting students' online learning outcomes. Table 3 shows the factors and sub-factors used in this study.

Table 3. Factors and sub-factors used in this study

No.	Factors	Sub - factors
1	**Instructor (IN)**	Attitude towards E-learning (IN1)
		Interacting with students (IN2)
		Technological capacity (IN3)
		Teaching performance (IN4)
2	**Students (ST)**	Technology skills (ST1)
		Learning motivation (ST2)
		Interaction with the instructor (ST3)
		Self-study ability (ST4)
3	**Course content (CC)**	Attractive course content (CC1)
		Use of Multimedia Instruction (CC2)
		Appropriate course content (CC3)
4	**Technology (TE)**	Easy to use (TE1)
		Friendly interface (TE2)
		Multiple functions (TE3)
		Reliability (TE4)

Tables 4-8 present the averaged comparison matrix of dimensions and factors assessed by the committee. These tables also show that the consistency ratio (CR) values of the committee are smaller than 0.1. Therefore, the committee's responses were consistent.

Table 4. Averaged comparison matrix of four factors assessed by the committee

Committee members	Factors	IN	ST	CC	TE
D1	**IN**	1.00	2.00	3.00	4.00
	ST	0.50	1.00	2.00	2.00
	CC	0.33	0.50	1.00	1.00
	TE	0.25	0.50	1.00	1.00
D2	**IN**	1.00	3.00	2.00	3.00
	ST	0.33	1.00	1.00	1.00
	CC	0.50	1.00	1.00	1.00
	TE	0.33	1.00	1.00	1.00
D3	**IN**	1.00	1.00	2.00	4.00
	ST	1.00	1.00	2.00	2.00
	CC	0.50	0.50	1.00	1.00
	TE	0.25	0.50	1.00	1.00
D4	**IN**	1.00	2.00	3.00	3.00
	ST	0.50	1.00	2.00	2.00
	CC	0.33	0.50	1.00	1.00
	TE	0.33	0.50	1.00	1.00
Averaged comparison matrix	**IN**	1.00	2.00	2.50	3.50
	ST	0.58	1.00	1.75	1.75
	CC	0.42	0.63	1.00	1.00
	TE	0.29	0.63	1.00	1.00

Note: CR (D1) = 0.006, CR (D2) = 0.006, CR (D3) = 0.019, CR (D4) = 0.009

Table 5. Averaged comparison matrix of foursub-factors with respect to "Instructor (IN)" assessed by the committee

Committee members	Sub-factors	IN1	IN2	IN3	IN4
D1	IN1	1.00	0.50	2.00	0.25
	IN2	2.00	1.00	4.00	0.50
	IN3	0.50	0.25	1.00	0.13
	IN4	4.00	2.00	8.00	1.00
D2	IN1	1.00	0.50	3.00	0.33
	IN2	2.00	1.00	4.00	0.50
	IN3	0.33	0.25	1.00	0.11
	IN4	3.00	2.00	9.00	1.00
D3	IN1	1.00	0.50	2.00	0.50
	IN2	2.00	1.00	3.00	0.50
	IN3	0.50	0.33	1.00	0.20
	IN4	2.00	2.00	5.00	1.00
D4	IN1	1.00	0.50	2.00	0.50
	IN2	2.00	1.00	2.00	0.50
	IN3	0.50	0.50	1.00	0.25
	IN4	2.00	2.00	4.00	1.00
Averaged comparison matrix	IN1	1.00	0.50	2.25	0.40
	IN2	2.00	1.00	3.25	0.50
	IN3	0.46	0.33	1.00	0.17
	IN4	2.75	2.00	6.50	1.00

Note: CR (D1) = 0, CR (D2) = 0.008, CR (D3) = 0.019, CR (D4) = 0.027

Table 6. Averaged comparison matrix of four sub-factors with respect to "Student (ST)" assessed by the committee

Committee members	Sub-factors	ST1	ST2	ST3	ST4
D1	ST1	1.00	0.50	3.00	2.00
	ST2	2.00	1.00	3.00	2.00
	ST3	0.33	0.33	1.00	1.00
	ST4	0.50	0.50	1.00	1.00
D2	ST1	1.00	0.50	2.00	3.00
	ST2	2.00	1.00	3.00	2.00
	ST3	0.50	0.33	1.00	0.50
	ST4	0.33	0.50	2.00	1.00
D3	ST1	1.00	0.50	2.00	2.00
	ST2	2.00	1.00	3.00	3.00
	ST3	0.50	0.33	1.00	0.50
	ST4	0.50	0.33	2.00	1.00
D4	ST1	1.00	0.33	2.00	3.00
	ST2	3.00	1.00	4.00	4.00
	ST3	0.50	0.25	1.00	1.00
	ST4	0.33	0.25	1.00	1.00
Averaged comparison matrix	ST1	1.00	0.46	2.25	2.50
	ST2	2.25	1.00	3.25	2.75
	ST3	0.46	0.31	1.00	0.75
	ST4	0.42	0.40	1.50	1.00

Note: CR (D1) = 0.041, CR (D2) = 0.081, CR (D3) = 0.043, CR (D4) = 0.005

Table 7. Averaged comparison matrix of three sub-factors with respect to "Course Content (CC)" assessed by the committee

Committee members	Sub-factors	CC1	CC2	CC3
D1	CC1	1.00	0.50	2.00
	CC2	2.00	1.00	4.00
	CC3	0.50	0.25	1.00
D2	CC1	1.00	0.50	3.00
	CC2	2.00	1.00	5.00
	CC3	0.33	0.20	1.00
D3	CC1	1.00	0.33	2.00
	CC2	3.00	1.00	4.00
	CC3	0.50	0.25	1.00
D4	CC1	1.00	0.50	4.00
	CC2	2.00	1.00	7.00
	CC3	0.25	0.14	1.00
Averaged comparison matrix	CC1	1.00	0.46	2.75
	CC2	2.25	1.00	5.00

	CC3	0.40	0.21	1.00

Note: CR (D1) = 0, CR (D2) = 0.021, CR (D3) = 0.049, CR (D4) = 0.019

Table 8. Averaged comparison matrix of four sub-factors with respect to "Technology (TE)" assessed by the committee

Committee members	Sub-factors	TE1	TE2	TE3	TE4
D1	**TE1**	1.00	0.50	4.00	1.00
	TE2	2.00	1.00	8.00	2.00
	TE3	0.25	0.13	1.00	0.25
	TE4	0.50	0.25	1.00	0.50
D2	**TE1**	1.00	0.50	4.00	3.00
	TE2	2.00	1.00	7.00	4.00
	TE3	0.25	0.14	1.00	0.50
	TE4	0.33	0.25	2.00	1.00
D3	**TE1**	1.00	0.50	3.00	3.00
	TE2	2.00	1.00	6.00	3.00
	TE3	0.33	0.17	1.00	0.50
	TE4	0.33	0.33	2.00	1.00
D4	**TE1**	1.00	0.50	4.00	3.00
	TE2	2.00	1.00	9.00	3.00
	TE3	0.25	0.11	1.00	0.50
	TE4	0.33	0.33	2.00	1.00
Averaged comparison matrix	**TE1**	1.00	0.50	3.75	2.75
	TE2	2.00	1.00	7.50	3.50
	TE3	0.27	0.14	1.00	0.63
	TE4	0.38	0.29	1.75	1.00

Note: CR (D1) = 0.013, CR (D2) = 0.027, CR (D3) = 0.034, CR (D4) = 0.01

Using the AHP approach and Tables 4-8, the weight vectors of the factors and sub-factors are obtained in Table 9. The results show that "Instructor" is the most important factor, following by "Student", "Course content" and "Technology".

Table 9. Weight vector of factors and sub-factors affecting students' online learning outcomes

Factors	Weight scores	Sub-factors	Weight scores
IN	0.449	**IN1**	0.165
		IN2	0.269
		IN3	0.078
		IN4	0.488
ST	0.254	**ST1**	0.226
		ST2	0.337
		ST3	0.092
		ST4	0.121
CC	0.152	**CC1**	0.299
		CC2	0.587
		CC3	0.114
TE	0.146	**TE1**	0.291
		TE2	0.510
		TE3	0.074
		TE4	0.124

V. CONCLUSION

Online learning plays an importance role in providing the ability to share information, increase interaction and create a good learning environment. This study applied the AHP method to determine the level of factors affecting student learning outcomes. Four factors were identified including instructor, student, course content and technologyat Amsterdam High School for the Gifted.The results indicated that "Instructor" is the most important factor affecting students' online learning outcomes at Amsterdam High School for the Gifted.

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