Key Success Factors for Learning Air Traffic Control
ปัจจัยแห่งความสำเร็จในการเรียนรู้การควบคุมจราจรทางอากาศ

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Received: October 1, 2020
Revised: November 3, 2020
Accepted: November 10, 2020

Abstract

This research aimed to prioritize Key Success Factors--KSFs for learning air traffic control by using Analytic Hierarchy Process--AHP approach, using Civil Aviation Training Center--CATC as a case study. The tools in this research were an assessment form for suitability of the KSFs in the context of CATC and an AHP-based questionnaire for pairwise comparison. This study reviewed the literature on key performance indicators and KSFs for learning air traffic control. Data on suitability of each KPI or KSF were collected using an assessment form developed based on literature review, in which the respondents were 20 instructors from CATC. The obtained data were the analyzed by one-sample t-test at a significance level of 0.05, and seventeen KSFs were then identified. It could be concluded that they were suitable in the context of CATC. Finally, these KSFs were prioritized by AHP approach by 14 aviation traffic controllers. Each of them had experience in fields at least eight years. The AHP results showed that the top three KSFs with the highest overall priority score were on the job training, planning for appropriate training and knowledge of air traffic control, and the learner's agreements, respectively.

Keywords: air traffic control, learning, Key Success Factors, Analytic Hierarchy Process

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อ จัดลำดับความสำคัญของปัจจัยแห่งความสำเร็จในการเรียนรู้การควบคุมจราจรทางอากาศ โดยใช้วิธีกระบวนการลำดับชั้นเชิงวิเคราะห์ (Analysis Hierarchy Process--AHP) และใช้สถาบันการบินพลเรือน (สบพ.) เป็นกรณีศึกษา เครื่องมือในงานวิจัยครั้งนี้ ได้แก่ แบบประเมินความเหมาะสมของปัจจัยแห่งความสำเร็จในบริบทของ สบพ. และแบบสอบถามสำหรับการเปรียบเทียบเชิงคู่ตามระเบียบวิธี AHP งานวิจัยนี้เริ่มจากการทบทวนวรรณกรรมที่เกี่ยวข้องกับดัชนีชี้วัดความสำเร็จและปัจจัยแห่งความสำเร็จในการเรียนรู้ จากนั้นแบบประเมินความเหมาะสมที่พัฒนาขึ้นเพื่อประเมินความเหมาะสมของปัจจัยเบื้องต้นที่ได้จากการทบทวนวรรณกรรมที่เกี่ยวข้องได้นำมาใช้เก็บข้อมูลความเหมาะสมของปัจจัยในบริบทของ สบพ. โดยผู้ตอบแบบประเมินคือผู้ฝึกสอนจาก สบพ. จำนวน 20 คน โดยข้อมูลที่เก็บรวบรวมได้จะนำมาทดสอบความเหมาะสมโดยการวิเคราะห์สถิติ t-test ที่ระดับนัยสำคัญ .05 ผลการทดสอบสรุปได้ว่าในมุมมองของผู้ฝึกสอน มีปัจจัยจำนวน 17 ปัจจัยที่มีความเหมาะสมที่จะเป็นปัจจัยแห่งความสำเร็จในการเรียนรู้การควบคุมจราจรทางอากาศ และเมื่อนำปัจจัยแห่งความสำเร็จเหล่านี้มาจัดลำดับความสำคัญโดยใช้วิธี AHP โดยผู้เชี่ยวชาญที่ทำการตอบแบบสอบถามการเปรียบเทียบเชิงคู่ คือ ผู้ที่มีประสบการณ์ด้านการควบคุมจราจรทางอากาศจำนวน 14 คน ซึ่งผลการวิจัยพบว่า ปัจจัยแห่งความสำเร็จที่มีค่าคะแนนความสำคัญมากที่สุดสามอันดับแรก คือ การฝึกการปฏิบัติงานจริง การวางแผนการฝึกปฏิบัติที่เหมาะสม และองค์ความรู้เกี่ยวกับการควบคุมจราจรทางอากาศและข้อตกลงต่าง ๆ ของผู้เรียน ตามลำดับ

คำสำคัญ: การควบคุมจราจรทางอากาศ การเรียนรู้ ปัจจัยแห่งความสำเร็จ กระบวนการลำดับชั้นเชิงวิเคราะห์

Introduction

At present, the transportation business is expanding and growing continuously. From the 2019 Annual Report of Airports of Thailand Public Company Limited, it found that in the fiscal year 2019 there was a 2.41% increase in commercial aircraft fluctuations compared to the fiscal year 2018 (Annual report of Airports of Thailand Public Company Limited, 2019) which can in turn cause the number of aircraft in Thai airspace (Bangkok Flight Information Region) to become heavy traffic. Therefore, in managing the air space (Airspace Management), it is necessary to have good planning for various commercial aircraft flight. From the ground (Komnamool, 2008), by being aware and giving great importance to safety, the number of aircraft increases controlling air traffic becomes more complex. Therefore, there must be officers' capability development by increasing learning as well, in which the International Civil Aviation Organization--ICAO has assigned the Air Traffic Controller--ATC is the person who responsible for handling and providing useful advice to aircraft. To ensure safety, orderly and smooth air traffic routes.

Currently, the production of basic air traffic controllers is carried out by the Civil Aviation Training Center--CATC, an institution that produces and trains air traffic controllers to have basic knowledge, skills and attitudes to meet the international standard. It is also an institute that has been approved by the Civil Aviation Authority of Thailand. The achievement of air traffic control learning is considered a prime goal of the institute

in the mission of producing air traffic controllers. The achievement of this learning a trainer in the Institute of Civil Aviation's Air Traffic Management course is essential to know the Key Success Factors--KSFs in air traffic control learning.

However, there are currently very few publications or research studies on the success factor in air traffic control learning. Therefore, to promote success in learning air traffic control, the researchers are interested to study the KSFs in air traffic control learning to know what factors affect the success of air traffic control. Besides, for effective learning, it is important to know the priorities of the factors in order to correctly and appropriately develop those KSFs in order of importance. This leads to suggestions as well as ways to increase efficiency in learning air traffic control.

Therefore, this study aimed to identify the list of KPIs and KSFs in the context of CACT, and KPIs and KSFs have been then prioritized by Analytic Hierarchy Process--AHP, a multi-criteria decision-making methodology which is "wildly applied in many areas because of its simplicity and robustness in obtaining weights and integrating heterogeneous data" (Gorsevski, Jankowski & Gessler, 2006, p. 128).

Literature Reviews

1. Air Traffic Control

Air traffic control is the work of safety services provided to aircraft in the sky, including ground vehicles or aircraft, and weather news. There are five objectives of air traffic management, which are (1) prevent the collision between aircraft, (2) prevent collisions between aircraft on the manoeuvring area and obstructions on that area, (3) expedite and maintain an orderly flow of air traffic, (4) provide advice and information useful for the safe and efficient conduct of flights, and (5) notify appropriate organizations regarding aircraft in need of search and rescue aid, and assist such organizations as required (Suklertnuntakij, 2001). Air navigation is the key to safety, followed by speed, where air traffic management must develop technology, knowledge and competence in order to effectively manage air traffic. To meets the air navigation laws and regulations. How to follow the correct steps (Panprasit & Somsuk, 2015), air traffic control service can be separated by area of services into 3 types: Aerodrome Control Services; Approach Control Services; and Area Control Services.

2. Learning on air traffic control

Learning is the awareness of new things that have happened. The things that will cause learning must pass the perception of the five senses, namely hearing, sight, taste, sense, touch, which is consistent with the research from (Teesuka & Uamcharoen, 2015, p. 44). Moreover, Gagne (1992) has seperated the theory of learning is divided into 9 categories: (1) gain attention is motivating learners to become more alert to generate interest in the content they learn; (2) specify objective is to let the students know the purpose of the study so that students can study by themselves in advance Including information from elsewhere; (3) activate prior knowledge is a review of previous knowledge from yesterday or that just happened to encourage students to relate new content to the original content; (4) present new information is presentation of new lessons do not be monotonous with the original story; (5) guide learning is the guidance instead of instructions for students to develop their own

ideas and to be independent of thinking; (6) elicit learning is the stimulation by asking questions or grouping to stimulate the lesson; (7) provide feedback is the providing recommendations for further development in the next study; (8) assess performance is the organizing a test in a small exam or make Q and-A questions to assess new knowledge gained; and (9) Review and transfer is the summarizing the entire content and applying it for further benefits.

3. Key performance indicators and key success factors for learning air traffic control

Key Performance Indicators--KPIs are defined as "quantifiable and strategic measurements that reflect the critical success factors" (ISO/DIS 22400-2, 2014) in the (learning) process. KPIs are very important for understanding, benchmarking and improving the performance of a system from both the process perspective and the corporate perspective of achieving strategic goals (ISO/DIS 22400-2, 2014).

Key success factors (sometimes referred to as critical success factors) are defined as "the limit number of areas in which results, it they are satisfactory, will ensure successful competitive performance for the organization" (Rockart, 1979).

In this study, the KPIs and KSFs for learning from many studies (e.g. Gardi, Sabatini, & Ramasamy, 2016; de Reuck, Donald, & Siemers, 2014; Updegrove & Jafer, 2017; Kuany, 2012; Reeves, 2005, etc.) have been reviewed and evaluated their suitability by instructors from CATC. So, the list of KPIs and KSFs has been identified in the context of CACT, and KPIs and KSFs have then been prioritized by AHP approach.

4. Analytic Hierarchy Process

Analytic Hierarchy Process was developed by Thomas Saaty in 1971 (Saaty, 1980; Saaty & Vargas, 1998). AHP is a multi-criteria decision-making method allowing decision makers to model a complex problem in a hierarchical structure which usually consists of the goal, objectives (criteria), sub-ojectives, and alternatives and to measure the consistency and stability of their decisions (Saaty, 1980; Shahin & Mahbod, 2007; Madu & Georgantzas, 1991; Madu, Kuei, & Madu, 1991). AHP uses pairwise comparison of the decision elements (usually, alternatives and attributes) to fine the comparative weights (scores) among the elements with respect to higher level element, or in other words, to prioritize the elements at each level of hierarchy. AHP method requires four major steps as follows;

1) Developing a hierarchy model: This step involves the decomposition of a complex problem into a multi-level hierarchical structure. AHP arranges the elements of decision into a hierarchy so that the relative role of each element can be more clearly observed and evaluated (Winebrake & Creswick, 2003). Developing a hierarchy model starts with identifying the meaningful and relevant elements of the problem, then grouping these elements into homogeneous sets, and finally arranging these sets in different levels of relevance.

2) Establish a pairwise comparison matrix: After the problem is arranged in a hierarchical structure, the next step is the measurement and data collection, which involves forming a team of evaluators and assigning parwise comparisons to evaluate the degree of relative importance amongst the elements (which may be called that "eigenvectors" or "the relative weights") in different levels of the hierarchies with respect to the higher level elements. Using the nine-point scale suggested by Saaty (Saaty, 1994), experts judge, using the pair-wise comparison approach,

the relative importance of the elements at the same level with respect to the element of their preceding level (Lam & Chin, 2005). The scale of importance is defined in Table 1 according to Saaty's nine-point scale for pairwise comparison. The nine-point scale is a scale of importance estimation ranging from equal to extreme importance: equal, moderate, strong, very strong and extreme importance. The numerical judgements corresponding to these linguistic descriptions are (1, 3, 5, 7, 9), with compromises (2, 4, 6, 8) between these judgements (Saaty & Vargas, 1998; Saaty, 1994) as shown in Table 1.

3) Checking the consistencies of the judgements: Consistency Ratio--CR is calculated to evaluate the consistencies of the judgements. Saaty (1994) suggested that if the CR is less than 0.1, then the judgement is acceptable. But if CR is equal or greater than 0.1, the judgement will need to be revised and re-evaluate until the value is less than 0.1.

4) Calculating the relative weights of the decision elements: This step innolves the finding of global or overall priority weights. Local weight, the priority of an element with respect to its preceding element, is firstly calculated. The overall weight of each element with respect to the goal is then calculated by multiplying the local weight of an element by the weight of its preceding element. The judgements of each decision maker (expert) are finally synthesized using the geometric mean approach suggested by Saaty (Saaty, 1990). The flow chart of AHP methodology is shown in Fig. 1.

Table 1

AHP preference scale (Saaty, 1994)

Importance Level	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values between the two adjacent judgements

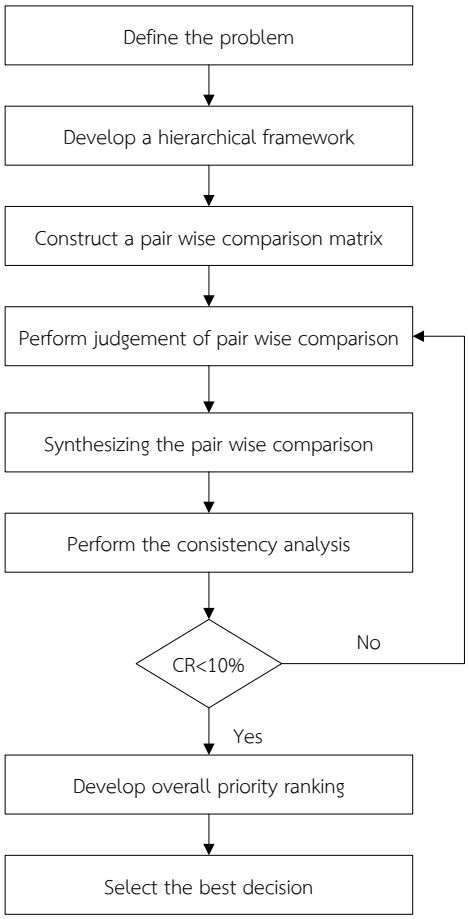

Fig. 1. Process flow chart of the AHP methodology

Note. From *Models, methods, concepts and applications of the analytical hierarchy process* (2nd ed.), by L. T Saaty and L. G. Vargas, 2012, New York:Springer Publishers.

Research Methodology

The research methodology in this study was divided into two phases as follows:

Phase 1: Determining the success factors in air traffic control learning

1. Literature review on KPIs and KSFs

2. Develope an assessment form for suitability of KPIs and KSFs in the context of CATC–the assessment form with 5-point Likert scale (1: least suitability, 5: most suitability) was developed based on the literature review result, after that the content validity of questionnaire was examined using IOC (Index of Item-Objective Congruence) by 3 experts.

3. Collect data (the suitability of KPIs or KSFs)–Data on suitability of each KPI or KSF were collected using an assessment form, in which the respondents were 20 instructors from CATC.

4. Evaluate a suitability of each KPI and KSF in the context of CATC using hypothesis testing: one-sample t-test with a significance level set at .05. The null hypothesis and alternative hypothesis are as follows,

H_0: $\mu \leq 4$ (KPI or KSF is not suitable in the context of CATC)

H_1: $\mu > 4$ (KPI or KSF is suitable in the context of CATC)

Note that the population mean setting of 4 (or test value=4) was consistent with many studies such as Angelova and Zekiri (2011); Aydin (2013); Bagwan and Bhola (2018); Khan, Zameer and Burney (2018); Khan, Nabi, and Hafeez (2016); Poku, Asare, and Ricky (2017); and Yadav (2018), etc.

The t value is calculated as follows: $t=(\overline{X}-\mu)/(S/\sqrt{n})$, where $\overline{X}$ is a sample mean, μ is a population mean, S is a sample standard deviation, and n is a number of samples.

If t is greater than this critical value ($t_{\alpha, n-1}=t_{0.05, 20-1}=1.729$), reject the null hypothesis. So, it can be concluded that the KPI or the KSF is suitable in the context of CATC at a significance level of .05.

Phase 2: Prioritizing KSFs for learning air traffic control using AHP

1. Establish a hierarchical structure for prioritizing KSFs in air traffic control learning

2. Develop a pair-wise comparison questionnaires based on AHP

3. Collect data (the suitability of KPIs or KSFs)–the pairwise judgement comparison data are collected through questionnaires. An expert panel composed of 14 aviation traffic controllers who had experience in fields at least eight years was asked to assess the relative importance of the KPIs and KSFs (to score (between 1–9; 1: lowest significance, 9: highest significance)).

4. Establish a pairwise comparison matrix extracted from questionnaires filled out by experts

5. Calculate the Consistency Ratio--CR of the matrices–the consistency ratio is calculated by CR=CI/RI, where CI is a consistency index, and RI is a random index. The CI is calculated by CI=(λ_{max} -n) (n-1), where λ_{max} is the largest eigenvalue of the n-order matrix, and n is the number of items being compared. If CR more than 0.1 or 10% the inconsistency of judgements within that matrix has occurred and the evaluation process will be reviewed, reconsidered and improved.

6. Combine the judgements from all experts by using geometric mean

7. Calculate the local priority weights of each element

8. Repeat the calculation of the local priority weights for all levels in hierarchy

9. Calculate the global priority weights of each element

10. Rank the priority of all elements based on their global priority weights

Research Results

1. Results of assessing the suitability of the KPIs and KSFs for learning air traffic control in the context of CATC

The literature review results on KPIs and KSFs for learning can be summarized in Tables 2 and 3, respectively (column 1). In this study, the KPIs and KSFs for learning are considered as the "preliminary performance indexs and preliminary success factors for learning in the context of CATC", in which there are five preliminary performance indexs and 23 preliminary success factors. Therefore, it needs to statistically assess them, to make sure that they are suitable to be KPIs and KSFs for learning air traffic control in the context of CATC, the case study, before prioritizing them by AHP in the next step.

An assessment form for suitability of KPIs and KSFs in the context of CATC, with 5-point Likert scale (1: least suitability, 5: most suitability), was developed–after that the content validity of questionnaire was examined using IOC by 3 experts. The result of overall IOC was at 0.8 which means the assessment form could be used. Data on suitability of each KPI or KSF were collected using the assessment form, in which the respondents were 20 instructors from CATC.

A suitability of each preliminary performance index and preliminary success factor was assessed its suitability in the context of CATC using hypothesis testing: one-sample t-test with a significance level set at .05. Results of assessing the suitability of the KPIs and KSFs for learning air traffic control in the context of CATC are shown in Tables 2 and Tables 3, respectively.

Table 2

Results of assessing the suitability of the KPIs for learning air traffic control in the context of CATC

Preliminary KPIs	Mean	Standard Deviation	t value	Hypothesis test results	Interpret results
Aviation knowledge	4.60	0.50	5.339*	Rejected H_0	Suitable
Skills	4.55	0.51	4.819*	Rejected H_0	Suitable
Attitude	4.65	0.49	5.940*	Rejected H_0	Suitable
Behavior	4.05	0.39	0.567	Accepted H_0	Unsuitable
Performance	4.25	0.44	2.517*	Rejected H_0	Suitable

Note: * at a statistical significance level of .05.

Table 3

Results of assessing the suitability of the KSFs for learning air traffic control in the context of CATC

Preliminary KPIs	Mean	Standard Deviation	t value	Hypothesis test results	Interpret results
On-the-Job Training	4.85	0.37	10.376*	Rejected H_0	Suitable
Educational Experience	4.30	0.57	2.349*	Rejected H_0	Suitable
Learning method /practice-based training	4.55	0.51	4.819*	Rejected H_0	Suitable
Learner and Instructor Interaction	4.05	0.69	0.326	Accepted H_0	Unsuitable
Accommodate Different Learning Styles	4.20	0.77	1.165	Accepted H_0	Unsuitable
Selection and use of appropriate and systematic teaching materials	4.05	0.60	0.370	Accepted H_0	Unsuitable

Table 2 (continue)

Preliminary KPIs	Mean	Standard Deviation	t value	Hypothesis test results	Interpret results
Good Theorectical Knowledge of procedure and agreements	4.40	0.50	3.559*	Rejected H_0	Suitable
Problem Solving Capabilitiy	4.50	0.69	3.249*	Rejected H_0	Suitable
Learning Capability	4.50	0.51	4.359*	Rejected H_0	Suitable
The ability to use technology	3.80	0.77	-1.165	Accepted H_0	Unsuitable
Learner Motivation	4.50	0.69	3.249*	Rejected H_0	Suitable
Learners' English language proficiency	4.20	0.62	1.453	Accepted H_0	Unsuitable
Updated simulation systems	4.40	0.68	2.629*	Rejected H_0	Suitable
Air Traffic Complexity	4.35	0.59	2.666*	Rejected H_0	Suitable
Suitable teaching materials	4.10	0.72	0.623	Accepted H_0	Unsuitable
Adequate teaching materials	4.35	0.67	2.333*	Rejected H_0	Suitable
Academic advising and monitoring learners' learning outcomes regularly.	4.55	0.60	4.067*	Rejected H_0	Suitable
Instructors Knowledgable	4.45	0.69	2.932*	Rejected H_0	Suitable
Planning for appropriate training	4.60	0.50	5.339*	Rejected H_0	Suitable
Up-to-date subject content	4.50	0.61	3.684*	Rejected H_0	Suitable
Appropriate subject content	4.45	0.69	2.932*	Rejected H_0	Suitable
Up to date course information	4.55	0.60	4.067*	Rejected H_0	Suitable
A commitment to support the learners from course directors	4.45	0.60	3.327*	Rejected H_0	Suitable

Note: * at a statistical significance level of .05.

According to the results from Table 2 and Table 3, four null hypothesis (H_0: $\mu \leq 4$) from Table 2 and seventeen null hypothesis (H_0: $\mu \leq 4$) from Table 3 are rejected. Therefore, it can be concluded that all four KPIs and seventeen KSFs which are suitable in the context of CATC at a significance level of .05. In this study, seventeen KSFs were classified into five categories: teaching methods and activities, learner, teaching equipments and technology, instructor, curriculum and course administrators.

2. Results of Prioritizing KSFs for learning air traffic control using AHP

After identifying the four KPIs and seventeen KSFs in the context of CATC, therefore, a hierarchical structure for prioritizing KSFs in air traffic control learning was established based on these KPIs and KSFs. The hierarchical structure is shown in fig. 2.

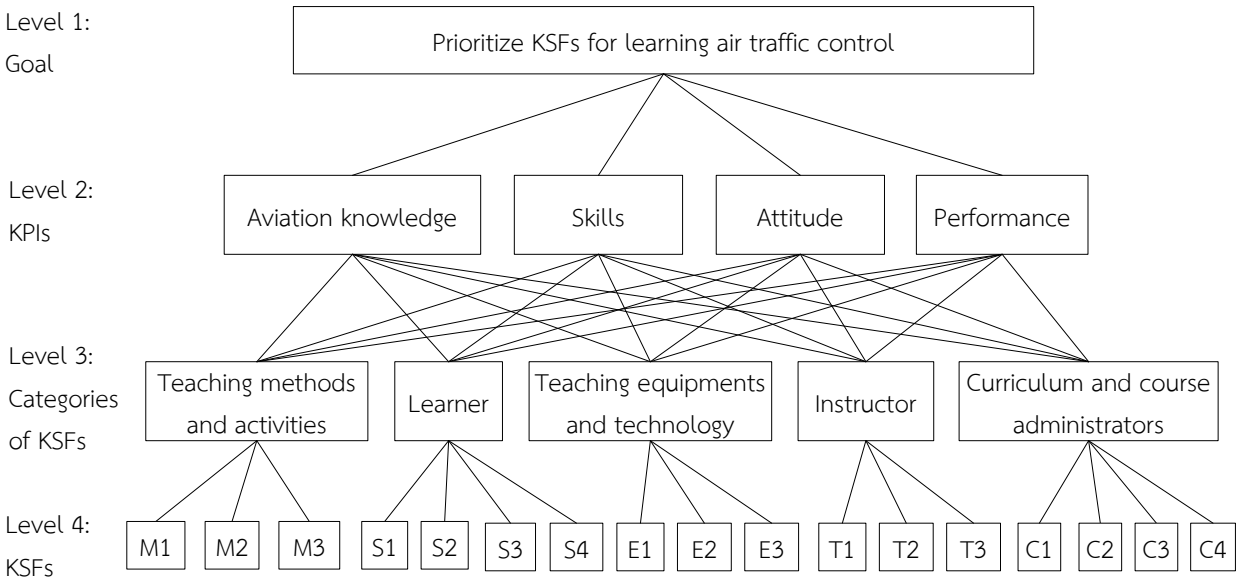

Fig. 2 The hierarchical structure for prioritizing KSFs in air traffic control learning for CATC

Figure 2 depicts a 4-level AHP model of prioritization of KSFs in air traffic control learning for CATC. The first level expresses the overall goal of this study, which is the prioritization of KSFs in air traffic control learning for CATC. The second level presents the four KPIs. The third level presents the five of categories of KSFs. The lowest level presents the 17 KSFs. These KSFs were prioritized by AHP approach by 14 aviation traffic controllers (or so called experts or decision makers). All experts had experience in fields at least eight years. The AHP results which are the priority weights and rankings of KPIs, categories of KSFs, and KSFs are shown in Table 4.

Table 4 shows the local and global weight scores of the KSFs and their categories. It also shows the results of prioritization of the KSFs in which the priority ranking of all KSFs is based on their global weights. From Table 6, in level 2, the most important (highest-global weight) KPI is "performance", followed by "skills", "attitude" and "aviation knowledge" respectively. In level 3, the category of "learner" is the most importance, followed by the categories of "instructor", "teaching methods and activities", "curriculum and course administrators", and "teaching equipments and technology" respectively, and in level 4, the three most important KSFs are "on-the-Job Training", "planning for appropriate training", and "good theorectical knowledge of procedure and agreements" respectively, while "educational experience" is the least important KSF.

Table 4

Local and global weight scores of the KSFs and their categories and their priority rankings

KSF categories	Local weights of KPIs				Global weights of KSF categories	KSFs	Local weights of KSFs	Global weights of KSFs	Priority rankings
	Aviation knowledge (0.151)	Skills (0.284)	Attitude (0.244)	Performance (0.320)					
Teaching methods and activities	0.193	0.212	0.186	0.219	0.205	On-the-job training (M1)	0.614	0.126	1
						Educational experience (M2)	0.146	0.030	17
						learning method /practice-based training (M3)	0.239	0.049	10
Learner	0.238	0.227	0.305	0.235	0.250	Good theorectical knowledge of procedure and agreements (S1)	0.294	0.074	3
						Problem solving capabilitiy (S2)	0.243	0.061	7
						Learning capability (S3)	0.283	0.071	5
						Learner motivation (S4)	0.180	0.045	12
Teaching equipments and technology	0.141	0.155	0.117	0.152	0.143	Updated simulation systems (E1)	0.318	0.045	12
						Air traffic complexity (E2)	0.416	0.059	8
						Adequate teaching materials (E3)	0.265	0.038	15
Instructor	0.228	0.215	0.240	0.222	0.226	Academic advising and monitoring learners' learning outcomes regularly (T1)	0.298	0.067	6
						Instructors knowledgable (T2)	0.326	0.073	4
						Planning for appropriate training (T3)	0.376	0.085	2

Table 4 (continue)

KSF categories	Local weights of KPIs				Global weights of KSF categories	KSFs	Local weights of KSFs	Global weights of KSFs	Priority rankings
	Aviation knowledge (0.151)	Skills (0.284)	Attitude (0.244)	Performance (0.320)					
Curriculum and course administrators	0.201	0.190	0.152	0.171	0.176	Up-to-date subject content (C1)	0.290	0.051	9
						Appropriate subject content (C2)	0.146	0.030	17
						Up to date course information (C3)	0.256	0.045	12
						A commitment to support the learners from course directors (C4)	0.214	0.038	16

Note: Parentheses ( ) denote the local weight of each KPI.

Conclusions, reccomendations, and future research direction

1. Conclusions

To prioritize KSFs for learning air traffic control, using CATC as a case study, this study was divided into two phases: (1) determining the KPIs and KSFs in air traffic control learning in the context of CATC, and (2) prioritizing KSFs for learning air traffic control using AHP.

In determining the KPIs and KSFs, data were collected by using an assessment form for suitability of the KPIs and KSFs in the context of CATC. By using one-sample t-test at a significance level of .05, the four KPIs and the seventeen KSFs from five categories: teaching methods and activities; learner; teaching equipments and technology; instructor; and curriculum and course administrators, were then identified as the KPIs and KSFs in air traffic control learning in the context of CATC.

In prioritizing KSFs: the 4-level AHP model of prioritization of KSFs in air traffic control learning for CATC was estabished. By using AHP approach, the priorities of all KSFs were ranked based on their global priority weights. The three most important KSFs are “on-the-Job training”, “planning for appropriate training”, and “good theorectical knowledge of procedure and agreements” respectively, while “educational experience” is the least important KSF. Besides, the three most important KSF categories are “learner”, “instructor”, and “teaching methods and activities” respectively.

2. Reccomendations

Recommendations for the CATC to be able to apply the research results effectively. As the results of the study showed “on-the-job training” is the most important KSF in learning air traffic control. For example, the course administrators should design the course to give learners the opportunity to improve themselves through effective learning

through hands-on experience in the form of "on the job training". The job assignments relevant to the contents of the course to be practical may be considered. To provide learners with a wide variety of knowledge and experiences, including to apply the acquired knowledge and skills in future operations, a learner development plan may be developed throughout the course, which is carried out through "on the job training" etc.

If "on the job training" is likely to improve the learners' achievement of air traffic control, the course administrators may also take the second most important KSF which is "planning for appropriate training" in order to find effective management solutions. And if the performance of the KSF is likely to result in a better way, other factors that are of secondary importance may be further considered.

3. Future research direction

1. Sensitivity analysis by exchanging the weights of KPIs (or criteria) should be further studied to account for the uncertainty of the outcomes.

2. To apply KSFs effectively, the best practice for each KSF, particularly, the KSFs that are of high importance should be further studied, such as best practice for on the job training, best practice on planning for appropriate training, etc.

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