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Valid Assessment of Transversal Competencies a Aircraft Maintenance: Insights from Focus Groups with Industry Stakeholders

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ABSTRACT

Aircraft maintenance training is shifting from time-based and theory-based toward Competency-Based Training and Assessment (CBTA), as promoted by the International Civil Aviation Organization (ICAO). This transition highlights the importance of non-technical, transversal competencies (TVCs), yet their assessments remain challenging. This study explores how TVCs can be assessed effectively in the context of aircraft maintenance by establishing the design requirements and methods using focus groups. Results indicate that programmatic approaches were preferred over traditional methods, particularly the use of personal competency portfolios integrating self, peer, and instructor assessments. Qualitative rubrics defining performance standards were identified as critical to ensure objectivity, supported by instructor training in evaluation and calibration. These findings provide practical guidance for embedding TVCs within aircraft maintenance training and assessment.

Introduction

Over the past few decades, due to technological changes improving aviation operations and safety (Amin et al., 2022; Ichou & Veress, 2023; Karakilic et al., 2023; Papanikou et al., 2021; Pereira et al., 2022; Stamoulis, 2022) aircraft maintenance technicians are operating in increasingly more complex environments which require specific competencies. However, training standards and regulations for aircraft maintenance technicians continue to focus primarily on theoretical multiple choice exams and time-based experience measures (Kearns et al., 2016; Zylawski & Ma, 2023). This approach contrasts with global trends in education, where educational programmes are shifting to CBTA (Catacutan et al., 2023; Chaney & Hodgson, 2021; McGrath & Yamada, 2023; Misko & Circelli, 2022) to address the growing demands of the rapidly changing job market requiring professionals to be flexible, adaptive, and equipped to respond effectively to new challenges. In this context, competencies and their valid assessments, rather than isolated knowledge and skills, are essential (Baartman et al., 2006; Frerejean et al., 2019; Gulikers et al., 2007; Mulder, 2014; Paeßens et al., 2023; Terzieva & Traina, 2015).

Training organizations offering basic training in aircraft maintenance are caught between adhering to traditional aviation regulations and, at the same time, preparing students for a dynamic work environment that demands competencies that are not consistently required in the regulations. These overlooked competencies mainly concern non-technical, transversal competencies (TVCs) that are often strongly related to human factors. TVCs are higher-order, non-subject-specific, and multidimensional competencies (Bray et al., 2020) that emphasize the correct application of both knowledge and skills (Winch, 2013). An example of a crucial TVCs for aircraft maintenance technicians to operate safely in the complex aviation environment is to communicate effectively in various situations (Korba et al., 2023; Newman & Scott, 2023). ICAO (2020) developed a competency framework to address the need for training to be more holistic and competency based, in contrast to the current standards (Airbus, 2022; Johnson, 2023; Zylawski & Ma, 2023) and articulates both technical and transversal competencies.

Our previous research revealed that the aviation industry considers communication as significantly more important than other TVCs from ICAO's competency framework for aircraft maintenance, followed by teamwork (Kes et al., 2025)

A paradigm shift in aircraft maintenance training

Replacing time-based requirements by CBTA would indicate a true paradigm shift for aircraft maintenance: Currently, the focus lies on theoretical multiple choice exams, and time-based practical experience (EASA, 2022; FAA, 2025; ICAO, 2022). In Europe, the theoretical training is hours-based (EASA, 2022). However, using multiple choice exams is less suitable for assessing complex competency development, since they are not very likely to elicit high level competence (Gulikers et al., 2018). They rarely go beyond the level of comprehension in Bloom's taxonomy for learning and do not even require recall but solely recognition of the correct answer (Biggs, 1996; Gulikers et al., 2018; Spencer & Spencer, 1993; Van der Vleuten, 1996a). Instead, competencies can only be assessed through observing one's behavior and performance (Gruppen et al., 2012; Gulikers et al., 2018; ICAO, 2020; McClelland, 1973; Miller, 1990; Spencer & Spencer, 1993).

Aim of this study

In this study, we aim to explore how student mastery regarding TVCs can be assessed effectively in the context of aircraft maintenance training. First, relevant findings from the literature are outlined. Second, these findings are integrated into an aircraft maintenance assessment concept. Third, this concept is validated by industry stakeholders through focus groups. Before detailing these various steps, the background of this study is explained below.

Background of this study

This study builds on prior research that identified the most critical yet difficult-to-assess TVCs and observable behaviors (OBs) from ICAO's aircraft maintenance competency framework through a global expert survey. A subsequent Delphi study refined these by defining performance levels, contexts, knowledge, skills, and attitudes (Kes et al., 2025). Using these standards, we examine in this study how students can be effectively assessed in relation to the following competencies:

- Competency 11 - Communication: "Communicate effectively in all situations and ensure clear and common understanding" with OB 11.4, "Maintains situational awareness when selecting method of communication, speaks clearly, accurately and concisely" and

- Competency 8 – Teamwork: "Operate safely and efficiently as a team member" with OBs 8.1, "Fosters an atmosphere of open communication," and 8.12, "Anticipates and responds appropriately to the needs of others" (ICAO, 2020).

Research questions

To establish a method for assessing communication and teamwork effectively on aircraft maintenance students, we formulated two research questions:

1. What are the design criteria for valid assessment of communication and teamwork?

2. What assessment methods are feasible for all stakeholders to summatively assess the OBs?

Requirements for Assessing Competencies

There is evidence in the literature that as competencies are context-dependent and related to specific tasks in a particular ecosystem, both training and assessment should take place in a relevant holistic environment. Using rubrics to provide detailed criteria with performance indicators for evaluation can assist objective assessments (Griffin et al., 2007; Krause et al., 2015). Evidence from both formative and summative assessments can be collected in a personal (electronic) portfolio for each student (Baartman et al., 2007; Biggs, 1996; Krause et al., 2015; Schuwirth & Van der Vleuten, 2011; Sluijsmans et al., 2008).

When designing holistic assessment methods, both feasibility and acceptability must be addressed, catering for different stakeholders like students, teachers and assessors, industry, and regulators. This could result in additional requirements, for example, when assessment methods should be implementable both in educational and real work settings (Norcini et al., 2011; Prescott et al., 2002). Gulikers et al. (2007) stress the importance of including students in the design process since they may differ from teachers and assessment designers in how they perceive the authenticity and meaningfulness of assessment tasks. Furthermore, relying on one single assessment to predict

future performance has been shown to be inadequate (Gulikers et al., 2018; Miller, 1990; Norcini et al., 2011; Terzieva & Traina, 2015; Van der Vleuten, 1996b; Van der Vleuten et al., 2012; Van der Vleuten & Schuwirth, 2005a). Therefore, an effective approach emphasizes the combination of a diverse range of assessment methods to ensure a reliable evaluation of performance (Australian Medical Association, 2022; Holmboe et al., 2010; Miller, 1990; Norcini et al., 2011; Prescott et al., 2002; Terzieva & Traina, 2015; Tikunoff & Ward, 1978; Van der Vleuten, 1996b; Van der Vleuten et al., 2012; Van der Vleuten & Schuwirth, 2005a). Assessors need training for a shared understanding and consensus regarding assessment outcomes to ensure validity and reliability (Terzieva & Traina, 2015).

Reliability, Validity and Acceptability

Choosing the right assessment methodologies implies compromising between reliability, validity, and acceptability, where sampling is more important for test reliability than standardization and objectivity. Especially the assessment of complex TVCs, requires professional judgement and, if appropriately sampled, can be sufficiently reliable without using highly standardized, structured and objective evaluations (Van der Vleuten, 1996a; Van der Vleuten & Schuwirth, 2005b). Consequently, assessment methods for TVCs are mainly based on qualitative, descriptive, and narrative information rather than numeric data (Van der Vleuten & Schuwirth, 2005b).

Another important aspect for choosing an assessment method is acceptability: Many (educational) professionals and organizations are driven by opinions, sentiments, and traditions (Van der Vleuten, 1996a). Given the paradigm shift this study represents in aircraft maintenance training, this is an important point of attention.

Assessing Communication and Teamwork

Regarding the assessment of communication and teamwork specifically, similar guidelines emerge from the literature. Because of its complex behavioral nature, communication should be observed directly in an authentic context over a longer period, and reducing communication skills to checklists assessments should be avoided (Van Den Eertwegh et al., 2014). Gilligan et al. (2024) state that diversity regarding gender, individual capabilities, cultures, and nationalities should be included in the assess-

ment context when assessing communication.

Using anonymized peer assessments emerge as useful in the training and assessment of both communication and teamwork. Using anonymized peer-assessments potentially reveals elements of team dynamics that may not be observable from outside (Jones & Abdallah, 2013; Van Helden et al., 2023) and are considered more reliable since teachers simply cannot oversee all team dynamics and its corresponding interactions (Farland & Beck, 2019; Strom & Strom, 2011).

Designing assessment concept

Using these guidelines, the first two authors, together with a small team of aircraft maintenance instructors, drafted an initial design for assessing teamwork and communication. In this design, various concepts from the literature were elaborated and visualized in a presentation tailored toward the context of aircraft maintenance training. The following elements were included:

- The concept of a personal portfolio containing a collection of assessment data;
- Rubrics for each OB describing the behavior on three different levels: Beginner, In Development, and Competent;
- The principle of holistic assessment; merging technical and transversal competencies;
- Various assessment methods; self-assessment, video assessment, peer assessment, and instructor assessment.

This initial design was then further reiterated and improved through various focus groups with different stakeholders.

Methods

The input from all stakeholders is pivotal to understanding the criteria for assessing TVCs in a valid and feasible way. This section will describe the methods used to answer the research questions.

Data collection

To establish the design criteria and meet the requirements regarding validity, reliability, and feasibility of the design for all stakeholders, several exploratory focus groups were applied. In focus groups, data is collected through group interaction on a topic determined by the researcher (Morgan, 1996). Focus groups are suitable for exploring both new ideas and examining existing ones and therefore useful to reveal understandings, opinions, views, and how these aspects are elaborated in a social group interaction (Wilkinson, 1998). Additionally, focus groups are useful when tacit knowledge is required as evidence (Ryan et al., 2014) or when stakeholders' engagement is required (Gibson & Arnott, 2007; Morcke et al., 2006; Pyrialakou et al., 2019; Tremblay et al., 2010). During a design process, stakeholders focus groups can deliver input to improve and refine the design (exploratory focus groups), and after implementation focus groups can evaluate the efficacy, quality, feasibility, and effectiveness of the design (confirmatory focus groups) (Gibson & Arnott, 2007; Tremblay et al., 2010). Focus groups are typically homogenous groups with six to eight participants but never more than 12, and sessions generally take one to two hours (Ryan et al., 2014; Tremblay et al., 2010; Wilkinson, 1998).

Focus groups formation.

Aircraft maintenance students, Maintenance, Repair and Overhaul (MRO) industry representatives, instructors, assessors, and regulators were recruited using the first author's network and snowball sampling: a recruitment method in which initial participants help identify or invite further participants from their own professional network. Four focus group sessions were conducted in total. One focus group consisted solely of students, while the other three included an international mix of aviation regulators, MRO representatives, instructors, and assessors from the United States of America, the United Kingdom, Greece, Turkey, and The Netherlands. The focus group with students was designed differently from those with other stakeholders to better reflect their perspectives, needs, and experiences. This will be further explained in the section about the study design. A total of 27 stakeholder representatives participated. One participant did not actively contribute and was therefore excluded from the dataset.

Demographic background

To gain a comprehensive understanding of the focus group participants, the demographic background is described where a distinction is made between students and other stakeholders, since their sessions were set up slightly differently.

Students

Students were recruited at MBO College Airport in The Netherlands, where instructors selected students based on their ability to constructively contribute to this study. In total, eight students were selected, and six students showed up at the focus group session. Their age ranged from 18 to 31 (average 25). Their educational background ranged from a bachelor's degree to no educational diploma. All students were enrolled in a full-time aircraft maintenance training program at MBO College Airport, with three students in year two and three in their fourth (final) year.

Other stakeholders

The three stakeholder focus group sessions consisted of six, five, and ten participants. Their age ranged from 30 to 69 (average 48). Figure 1 shows the roles participants held within aviation, excluding those related to training and assessment, which are presented separately in Figure 2.
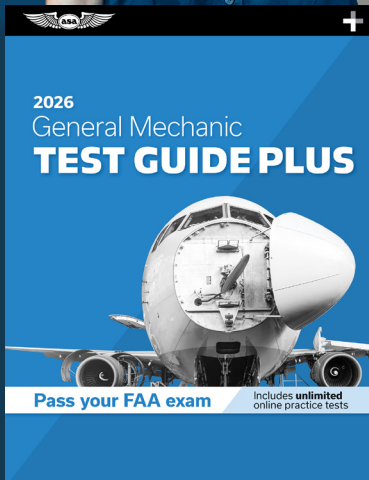
Figure 1

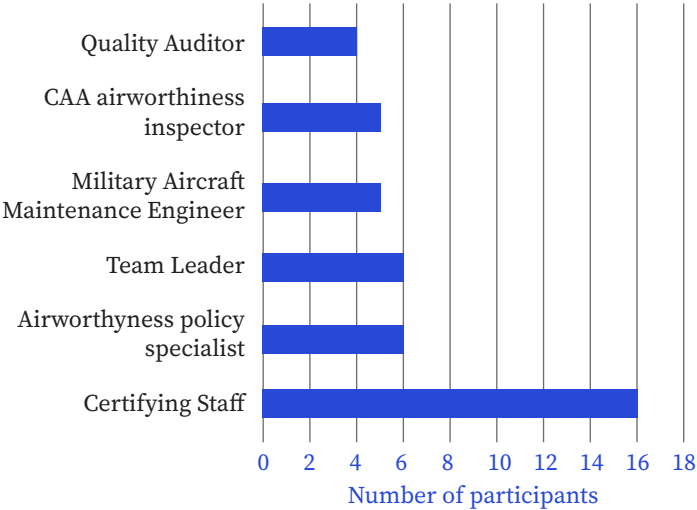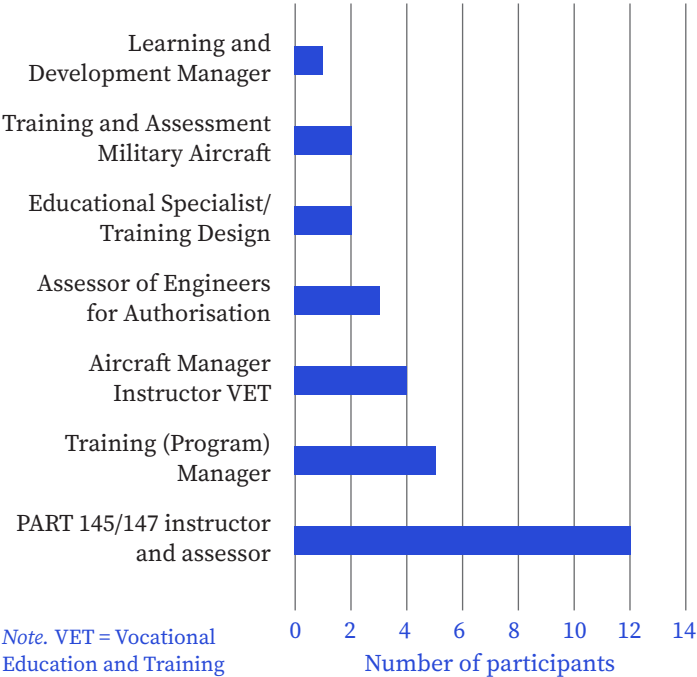Experience in Aviation Maintenance Excluding Training and Assessment (*n* = 20)

Table 1 shows the roles the participants held while participating in the focus groups, where some participants held more than one role at the time. Each participant was asked to report their strongest expertise. This is shown in Table 2.

Table 1

Professional Roles of Participants During Focus Group Participation (*n* = 20)

Current role in Aviation Maintenance	*n*
Manager / Supervisor Technical Training	6
Instructor Aircraft Maintenance PART 145/147	5
Instructor Aircraft Maintenance VET	3
Airworthiness Policy Expert / Specialist	3
Program Manager Innovation, Training & Education	2
Aircraft Maintenance Training Design	1
Director of Regulatory and Technical Operations	1
Human Resources	1

Figure 2

Experience in Aviation Maintenance Training and Assessment (*n* = 20)

Note. VET = Vocational Education and Training

Table 2

Strongest Expertise of Each Participant (*n* = 20)

| Strongest Expertise	*n*
Aircraft Maintenance Training and Assessment	7
Aircraft Maintenance	3
Aircraft Maintenance Training Design & Development	3
Regulation	2
Maintenance Manager	1
Training Management	1
Safety, Compliance, Quality, Regulatory, and Technical	1
Rulemaking, Standardization, and Oversight	1
Human Resources	1

Study design

Figure 3 shows the structure and flow of the focus group sessions. The sessions were guided by concepts and examples presented on slides, along with topic-related questions. Participants received a detailed explanation of the study's background. Additionally, key concepts were explained to ensure common understanding. All participants were encouraged to speak freely and to not feel pressured to conform if their views differed.

Figure 3
Schematic Display of Focus Group Sessions
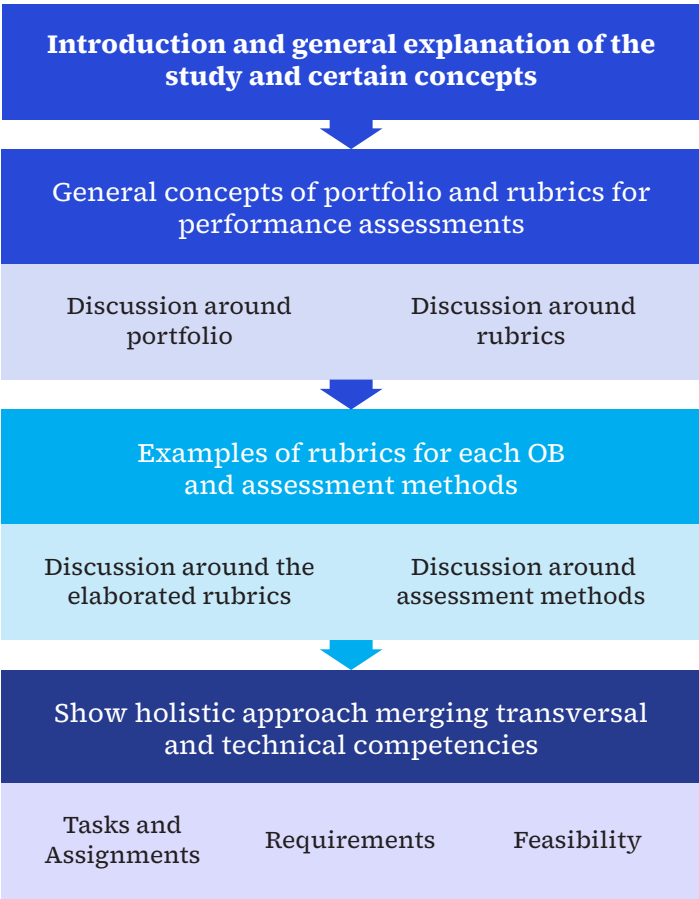
The student session focused on their opinions, ideas, and needs in relation to the assessment of communication and teamwork. In contrast, the other sessions also examined the feasibility of the assessments within various contexts, including VET organizations, other aviation training organizations (Part 145 and 147), and relevant regulatory oversight requirements.

All sessions took place in the summer of 2025 and were moderated by the first author. Two sessions were face-to-face, and two were held online. They were recorded and transcribed using Microsoft Teams. The second author attended all sessions to make notes and monitor the recordings and transcriptions. The third author attended the first two sessions to make notes and monitor the flow of the process. Ethical permission was granted by the university's Human Research Ethical Committee, reference number 5465.

The transcripts were checked for accuracy and readability against the original recordings and then anonymized and coded using Atlas.ti, followed by further analysis and categorization to extract the main themes by the first and second author. Any ambiguous areas were jointly reviewed and re-examined using the transcripts for clarification.

Results

The main findings are discussed per category: design requirements and assessment methods. The data represent consensus among the participants unless otherwise reported. For findings that are the product of collective sensemaking, the discussion process is also described.

Design Requirements

Several concepts have been explored during the focus group sessions:

- Multiple assessments documented in a personal portfolio;
- Rubrics describing different performance levels;

The personal portfolio comprises a collection of performance assessment results obtained through various assessment methods, all standardized by rubrics and conducted in authentic contexts. The assessment methods and authentic contexts are discussed below. First, the design requirements of the portfolios themselves, including the rubrics used for the performance assessments, are discussed. When needed, the views of the students and other stakeholders are separated to enhance clarity.

Portfolio with multiple assessments

The students were unanimously in favor of this concept. Collecting several assessment data of performance, rather than one final summative assessment, was associated with both a decrease of pressure and a more objective performance measurement: "This is so much better than just one large final exam. That's just a snapshot. A portfolio will take away so much pressure!" "If you had a bad day and then you have to do your final assessment then you may fail even though the whole year you were doing well and then you don't pass."

There were some concerns regarding the objectivity of the instructors: "If you don't click with your instructor this may affect his objectivity." Another concern was the standardization of the assessments: "You need standards, otherwise instructors will add their own flavor and then it's less objective." Although instructor objectivity was a concern, the students remained ambivalent whether to change instructors regularly to ensure objectivity:

> Having the same instructor for a long time can also really add value. This way he has much more time to understand your progress and he can get to know you better and see things that another instructor probably wouldn't see in a short period.

The other stakeholders also expressed a positive attitude toward personal portfolios documenting multiple assessment datapoints. All participants reported that this method would be feasible in their contexts but listed prerequisites for implementation:

> I think it's really good. I can work with this. I have students who perform so much better than others, you would actually like to get them through sooner, while others need more time. With a portfolio you can do that as long as it is filled properly. You need good rules, good conditions for that.

Another commented, "It should be possible. Companies already have processes with evaluations and performance appraisals." A striking finding was that in all three focus group sessions, the MRO industry representatives expressed their concerns regarding conflict of interest versus objectivity. When a company is short of staff with certain licenses or authorizations, there is a need for candidates to pass assessments, which may bias the assessor. The

participants would prefer to outsource the assessments to training organizations only, to avoid bias.

> In your own company there's more pressure to let the guy pass. You know, when there's no pressure, you can assess the guy as it is. But if you're in a team and the boss is knocking on your door, "I need him tomorrow," you know you cannot fail this one.

Another important finding is that when participants were discussing the portfolio requirements from a regulatory perspective, a national NAA representative said: "anything will be an improvement to what regulators do today regarding evidence of performance," to which all participants agreed.

Table 3 shows the overall findings of the stakeholders' views (without the students). When comparing the different requirements mentioned by all stakeholders (students included) most prerequisites mentioned involve standardization and oversight, taking up two thirds of all requirements. The other third is divided into didactical requirements and objectivity issues. Even though some requirements were mentioned more frequently than others, they were treated equally since there were no objections. Figure 4 shows the proportion of the various types of requirements the participants suggested.

Figure 4
Types of Requirements Related to a Portfolio with Multiple Assessments

- Didactics — 17%
- Oversight — 33%
- Objectivity — 17%
- Standardisation — 33%
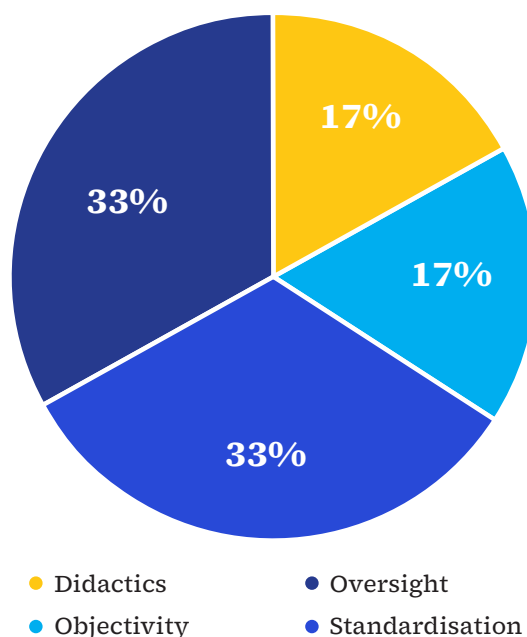
Table 3
Other Stakeholders' Focus Groups Findings on a Portfolio with Multiple Assessments

Opinion	Requirements
Enhances self-paced learning.	Recording evidence properly to avoid fraud.
More reliable due to both frequency and context variation of performance.	Avoid (financial) conflict of interests in maintenance organizations.
Not only enhances transparency on progress but allows to intervene accordingly.	Alignment of assessments in increasing complexity for holistic interpretation.
Enhances ownership for the student and employee and provides context for self-assessment.	Level of assessment should match training stage.
Very useful to continue after licensing when working.	Requirements from regulators regarding evidence - conditions a portfolio must meet.
	The assessment information behind the data should be accessible for audits.
	Solid criteria for portfolios and the assessments they are based on.
	The portfolio needs to be standardized to a level that it facilitates the portability between MROs.
	Regulators will need evidence of consistent performance relative to the standard.
	A data collection methodology to gather, process, and analyze data, enabling the assessment programme to distinguish competent students from those who are not.

Rubrics describing different performance levels

Tables 4, 5, and 6 represent the proposed rubrics discussed, in which two minor suggestions from the participants have been included. All stakeholders viewed the rubrics as very helpful and very clear. A student mentioned: "This is very clear; you understand exactly what behavior is required," and another student added: "This avoids discussion because it is written down exactly what is required." One instructor reacted: "This makes me really happy. This really helps to monitor and evaluate performance. I could easily just put a group of students at work and then monitor where they stand." An industry representative said, "With rubrics like these it is easier to assess, and it will contribute to the acceptance of the students into the organization if we all use this methodology." However, the students were unsure about the rubric of OB 11.4: "When we are working on a task, we are talking all day about everything. So, a lot of unnecessary information will be communicated."

When it was explained that the focus was on communicating key information to a colleague or supervisor—rather than everyday communication—they suggested it would help to create a clear assessment context, such as a role-play element. Role-play will be further discussed in the section about tasks and contexts.

With regard to the rubric of OB 8.12, a participant pointed out that it was difficult to measure whether a student "notices" something since this is an internal cognitive process. For example, the draft rubric described at the "competent" level: "The student/employee always immediately notices from the body language of his/her fellow student/colleague that he/she needs help". The instructor commented: "You don't know what someone notices, only when he acts on it."

Collective Sensemaking on Narrative Rubrics

In one focus group, a discussion emerged regarding the qualitative descriptions of the behaviors. One participant pointed out:

> It is always debatable what is good enough. Does "always" mean 100% of the time or 99%? You could quantify the levels by saying a good assessment is that more than 90% of the cases you have shown that be-

havior and a bad assessment is less than 10%, or any scale like that. I don't like that too much because then it becomes a mathematical exercise and that should not be the case.

After a discussion over "how many, how often" and the ORCA method (Observe, Record, Classify and Assess/Evaluate), the group collectively concluded that quantifying behavior was not their preference when assessing TVCs like communication and teamwork. However, good guidance material for the assessor on how to manage the rubrics used for the assessments becomes necessary.

Authentic Assessment Contexts

When discussing what types of tasks or assignments could operationalize these competencies for assessment purposes, participants proposed various approaches, involving three key elements: environment/context, tasks, and scenarios, which were sometimes combined. All focus groups considered role-play as a suitable approach for both training and assessment, allowing specific scenarios to be practiced. While students acknowledged that role-play might sometimes feel unnatural, they still favored its use. Several instructors reported that they were already using this approach successfully.

Closely related to this, the importance of authenticity was emphasized in various ways, in which a form of simulation

Table 4
Discussed Rubric for Training and Assessment of Observable Behavior 11.4 of ICAO's Competency Framework

Competency	Observable Behavior	Beginner	In development	Competent
Competency 11 – Communication: 'Communicate effectively in all situations and ensure clear and common understanding'	11.4 Maintains situational awareness when selecting method of communication, speaks clearly, accurately and concisely.	When communicating, the student/employee does not distinguish between information that is or is not safety critical. Therefore, a lot of unnecessary information is communicated and/or essential information regarding safety is omitted.	When communicating, the student/employee makes some distinction between information that is or is not safety critical. Some redundant information is still communicated and/or some essential information is still omitted regarding safety.	The student/employee communicates only information that is in the interest of safety. No unnecessary information is communicated.
		The student/employee usually or always automatically assumes that the information they communicate is clear to the recipients, without checking this.	The student/employee sometimes automatically assumes that the information they communicate is clear to the recipients, without checking this, or only checks this with a few recipients.	The student/employee never automatically assumes that the information they communicate is clear to the recipients and therefore always checks this with all recipients.
		When the student/employee receives verbal information, they do not check whether they have understood it correctly.	When the student/employee receives verbal information, they sometimes check whether they have understood it correctly. For example, if they are not completely sure.	When the student/employee receives verbal information, they always check whether they have understood it correctly by repeating it, possibly in different words.
		The student/employee makes many assumptions during their communication, without checking whether those assumptions are correct.	The student/employee makes some assumptions during their communication, which should have been checked.	The student/employee does not make assumptions but always checks first whether they are correct.

predominates. Table 7 summarizes the approaches considered valid for training and assessment by all participants, using their own words as much as possible. Duplicate suggestions have been removed; however, some overlap or similarity between certain methods may still be noted. All suggestions were considered feasible by all stakeholders, although many participants representing the MRO industry recognize that it increases the workload.

> What makes it difficult is that those competencies need to be continuously observed and often they also have to pass for their PART modules and then this comes on top of it. We're almost a training organization rather than a maintenance organization.

On the other hand, several MRO industry representatives shared that some methods are already being explored in their organization for the purpose of Lifelong Learning of personnel.

Assessment Methods

Several methods to measure and document performance of communication and teamwork have been discussed in all focus group sessions: video assessments, self-assessments, peer-assessment, and instructor assessment, using the rubrics as a reference. Although formative assessments were mentioned by some participants, they mainly approached the assessments as summative elements of the assessment data collection of the personal portfolio.

Students Focus Group Results

One interesting finding is that the students were very critical toward video assessments. Not so much because of privacy reasons, but because of its unauthenticity. As one student described: "Making a video of your performance seems forced and unnatural. Then you're more focused on making a good video than on the actual performance that is being measured." Students favored self-assessments and instructor assessments, if the instructor is objective

Table 5

Discussed Rubric for Training and Assessment of Observable Behavior 8.1 of ICAO's Competency Framework

Competency	Observable Behavior	Beginner	In development	Competent
Competency 8 – Teamwork: 'Operate safely and efficiently as a team member'	8.1: Fosters an atmosphere of open communication.	The student/employee shows little to no interest in their fellow students or colleagues.	The student/employee shows some interest in their fellow students or colleagues.	The student/employee shows interest in their fellow students or colleagues.
		The student/employee does not ask any questions, especially if they feel that it concerns something they should know.	The student/employee asks some questions, sometimes even if they feel that it concerns something they should know.	The student/employee asks a lot of questions, even if they feel that it concerns something they should know.
		The student/employee does not discuss it with fellow students/colleagues or teacher/supervisor if they have made a mistake.	The student/employee sometimes discusses it with their fellow students/colleagues or teacher/supervisor if they have made a mistake, or limits this to one or a few team members.	The student/employee always discusses it with their fellow students/colleagues or teacher/supervisor if they have made a mistake and involves all team members in this.
		The student/employee involves few or no team members in their communication, even though it is important for the other team members.	The student/employee involves some team members in their communication, but not all team members for whom it is important.	The student/employee involves all team members for whom this is important in their communication.

and not biased by any previous performance or behavior. Using the rubrics was another requirement to avoid discussions or personal opinions. When discussing the possibility of using technological applications like VR, the students were skeptical: "We have done some things in VR like an inspection, and you walk through an airplane and you can see inside the airplane. It was funny, but it didn't really add anything. It's just not realistic enough." Another student questioned the reliability of using VR in general: "Even if it would be super realistic; you may excel in racing games, but that doesn't make you a Formula 1 driver."

Collective Sensemaking on Peer-Assessments

The students unanimously regard peer assessment as both valuable and desirable. Not only were they considered useful to decrease the burden of the instructor but also to decrease stress levels of the students: "It takes away the stressor of having the instructor's eyes on you. Instead, you're just working with one of your peers."

However, opinions were divided on whether such assessments should be anonymous. Some students stated that anonymity is necessary to provide honest feedback, particularly when addressing a peer's poor performance. Others argued that feedback should be given openly, as this allows

Table 6

Discussed Rubric for Training and Assessment of Observable Behavior 8.12 of ICAO's Competency Framework

Competency	Observable Behavior	Beginner	In development	Competent
Competency 8 – Teamwork: 'Operate safely and efficiently as a team member'	8.12: Anticipates and responds appropriately to the needs of others	The student/employee does not respond to non-verbal cues such as body language from peers or colleagues indicating a need for help.	The student/employee sometimes responds to non-verbal cues such as body language from peers or colleagues indicating a need for help.	The student/employee usually or always responds to non-verbal cues such as body language from peers or colleagues indicating a need for help.
		The student/employee does not offer support when a peer or colleague has been working on a task for an extended period without progress	The student/employee sometimes offers support when a peer or colleague has been working on a task for an extended period without progress	The student/employee usually or always offers support when a peer or colleague has been working on a task for an extended period without progress
		The student/employee never proactively offers their help.	The student/employee sometimes proactively offers their help.	The student/employee usually or always proactively offers their help.
		When the student/employee offers assistance, they take over the task completely without explaining to the fellow student/colleague what to do, or does so in a hurry/stressed manner.	When the student/employee offers assistance, they take over to some extent, but still involve the fellow student/colleague to some extent in completing the task. They may do this in a hurry/stressed manner.	When the student/employee offers assistance, they calmly guide(s) the fellow student/colleague through the process and in this way they complete the task together.
		The student/employee does not handle the observed information about their fellow student/colleague discreetly and confidentially before, during or after they have helped them.	The student/employee handles the information observed about their fellow student/colleague in a partially discreet and confidential manner before, during or after they have helped them.	The student/employee handles the information observed about their fellow student/colleague discreetly and confidentially before, during and after they have helped them.

Table 7
Main Findings: Training and Assessment Approaches for Communication and Teamwork

Training and Assessment Approaches	Simulation Category
Daily jobs and tasks	Tasks
Troubleshooting, inspection; challenging tasks	Tasks
Create tasks you cannot perform alone	Tasks
Role play	Scenario
In base maintenance you can simulate line maintenance by creating scenarios	Scenario
Increase complexity like AOG with 180 pax and a nervous pilot, or a phone call that another aircraft comes in	Scenario
Simulate that students are in charge	Scenario
Variety in team so you are consistent with your behavior	Environment
Some elements of communication and teamwork don't have to be trained around an aircraft	Environment
Simulate base or line maintenance in a training hangar	Environment
Instructors set the right example - practice what you preach	Environment
Simulate communication and teamwork in the shops when you start building up training. It doesn't have to be around an aircraft.	Environment
Activities that are progressively unstructured by ramping up the number of stressors.	Scenario & Environment
Simulation or real MRO context and tasks	Environment & Tasks
Simulate operational environment where collaboration is imperative. Let them do things they can't do alone.	Scenario & Tasks
Create realistic scenarios using the MEL and ETOPS	Scenario & Tasks
Simulate that they are leading an A-check	Scenario & Tasks
Designate students as team lead and let them do a shift handover when another group of students comes in	Scenario & Tasks
Create scenarios where you have to rely on each other'scommunication because you can't see each other, for example when one is rigging the flight controls and the other student is in the cockpit moving the flight control to place the rigging pin. Or when one is in the fuel tank and the other student has to hand him the tools he needs.	Scenario & Environment & Tasks

Note. AOG = Aircraft On Ground; MEL = Minimum Equipment List; ETOPS = Extended-range Twin-engine Operational Performance Standards.

for constructive dialogue and mutual understanding. They found that, in a way, anonymous feedback can be considered as socially unsafe.

The students acknowledged that in professional settings feedback is rarely anonymous and being open supports the development of a culture of transparent communication. They stressed the importance of introducing peer feedback from the very beginning of the program to help students become comfortable with the process over time. As a compromise, the group agreed that anonymity is not essential if feedback discussions take place in a small, safe setting—ideally with no more than four participants, of which at least one is an instructor.

Other Stakeholders

All participants expressed support for self-assessments, peer assessments, and instructor assessments—particularly favoring a combination of these approaches. The rationale for endorsing specific types of assessments varied, with several participants emphasizing that the purpose of assessment can extend beyond measuring performance. In some cases, the methods were seen as valuable, highlighting their formative potential. For instance, self-assessment was viewed not only as a tool for evaluation but also as a means of fostering reflection—an aspect participants considered essential in a safety-critical environment such as aviation. One instructor explained: "I noticed that students do not always know themselves so well. They tend to overestimate their performance. Comparing their self-assessments with my own observations and discussing with them what they could improve helps them reflect."

Regarding peer-assessments, one participant shared how using peer-assessments in their maintenance organization enhanced mutual recognition within their team, having a positive impact on their teamwork.

Instructor assessments were considered as the most reliable, but not always feasible due to the workload for the instructor. A few participants stated that at least two assessors are needed for objectivity, but this was not a general finding from the discussions.

When it came to the use of digital tools and applications such as AI, only one participant expressed strong enthusiasm, while another saw digital tools as more appropriate

for training purposes rather than assessment. The most optimistic participant suggested that recording performance on video and using AI to analyze it could increase the amount of feedback provided. Although many participants acknowledged the time-consuming nature of giving narrative feedback, there was limited support overall for the use of digital tools in assessment. Video-based assessments were also not favored—primarily due to concerns about privacy. However, a few participants did note that such recordings could serve as reliable evidence for audit purposes.

Table 8 outlines the requirements the participants considered essential for each assessment method. Many prerequisites concern thorough training for all stakeholders.

Table 8
Requirements for Different Assessment Methods

Assessment Method	Requirements
Instructor Assessment	• Instructor must be objective and not biased • Clear rubrics must be used • Training is needed for instructors and assessors.
Self-Assessment	• Students need to be trained on doing this; start practicing early in the training program
Peer-Assessment	• Students need to start early to practice being objective and taking it seriously • Clear rubrics must be used • Feedback in a safe, small group setting with at least one instructor present

Discussion

Many elements drawn from the literature were incorporated into the presentation for the focus groups to respond to, such as the concept of a portfolio, rubric examples developed from previously defined performance levels, and proposed assessment methods. Overall, the participants responded positively to these approaches. This indicates that the literature on this subject is highly applicable to CBTA in aircraft maintenance.

Looking more closely at the first set of more detailed ideas—such as the rubrics—it is noteworthy that, through collective sensemaking, one focus group concluded that numerical scoring was not preferred for assessing TVCs, even though the narrative rubrics allowed room for interpretation. This aligns with findings in the literature, which suggest that the assessment of complex TVCs is primarily based on descriptive, narrative information rather than quantitative data. Other focus groups immediately encouraged the descriptive nature of the rubrics.

Another notable outcome from the more directive elements discussed, was the students' final agreement that peer assessments should not be anonymous, as anonymity could itself create a socially unsafe environment. After weighing the pros and cons, they decided through collective sensemaking that anonymity was not needed, but that feedback should be given in a small, safe setting. This stands in contrast to the literature, where anonymized peer assessments are often recommended as effective for training and assessing communication and teamwork competencies. A plausible explanation for this discrepancy could be that aviation students are educated within a "just culture" philosophy, which emphasizes open discussion of mistakes and near-misses without fear of punishment to foster collective learning and improve team safety.

Regarding the rubrics, it was noted that the rubric for OB 8.12 was flagged for including a cognitive process that cannot be directly observed by the instructor and therefore should be revised. Interestingly, the rubric for OB 11.4 also involves a cognitive process, using the term "assume," yet the participants did not comment on this. A possible explanation is that the associated action—checking with the recipients of the communication—is clearly defined and observable, which may have made the cognitive element

less problematic.

Limitations

Of the 27 participants, 26 provided valuable input, but the number of student participants was relatively small. Students needed to be available, motivated and capable of contributing constructively, which limited the selection. Additionally, all student participants came from the same college; a more diverse group with varied educational and internship experiences might have influenced the findings.

The current study included four focus group sessions with different stakeholders from five different countries. Although many consistencies were found among the focus group sessions, having more stakeholders available representing the students, regulators and maintenance (training) industry may have impacted the results.

Conclusion

In this study, we aimed to identify valid and feasible methods for assessing OBs 11.4, 8.1 and 8.12 from ICAO's Competency Framework for Aircraft Maintenance.

Design Criteria

The design criteria are addressed by research question 1: What are the design criteria for valid assessment of communication and teamwork? Based on the results, the following criteria are outlined.

Portfolio with multiple assessment datapoints

Using a portfolio with multiple performance assessments is preferred over one final summative assessment. It is deemed more reliable, more transparent, and it enhances self-paced learning. The latter is not only because it reinforces ownership by the student, but also because it supports student-level interventions by the instructor. Finally, it is considered less stressful for students. Furthermore, the attributed value of a portfolio went beyond obtaining a license and was considered a useful tool for documenting lifelong learning and development post-licensing.

Requirements for portfolio implementation

Most of the conditions suggested by the participants concerned standardization and oversight. In essence, it comes

down to having solid criteria and a standardized method for collecting, processing, and analyzing assessment data and how this can be used for audits by the regulators. However, standardization was not only emphasized for oversight purposes, but also for (international) transferability among organizations. To a lesser extent, didactic requirements and aspects regarding objectivity are deemed important: The level of assessments should match the training stages applying increasing complexity in a holistic training environment, and instructors and assessors should be objective and unbiased.

Textual Rubrics

The rubrics demonstrated in tables 4, 5, and 6 are considered very clear and useful both for training and assessing the OBs of focus. Although the rubrics are fully narrative and may leave room for interpretation, this approach is preferred over quantitative scoring due to the nature of the competencies. Moreover, the rubrics were seen as an effective way to address concerns about objectivity and standardization. However, clear guidelines for the teacher and assessor are needed to support the correct scoring of performance.

Approaches to operationalize communication and teamwork

To elicit the demonstration of these competencies for assessment purposes, several approaches were deemed both valid and feasible. The approaches all indicate a form of simulation and can be discerned by tasks, scenarios, and environments but were also described by a combination of these aspects.

Tasks

All participants agreed that training and assessment should be done through daily jobs and tasks. For these competencies, tasks involving inspection and troubleshooting were deemed suitable, preferably those that can not be done by one person alone and that challenge students.

Scenarios

All participants considered role-play a strong approach to embed the tasks in meaningful scenarios. More detailed examples to create a realistic context for students are sim-

ulating line maintenance events, such as communication scenarios with pilots during AOG, simulating a supervising role for the student leading an A-check, or doing shift handover. Also, scenarios using the MEL and ETOPS are considered useful for assessing communication and teamwork. In general, it was considered essential to combine tasks and scenarios that require collaboration and mutual reliance.

Assessment Methods

The assessment methods are addressed by research question 2: What assessment methods are feasible for all stakeholders to summatively assess the Observable Behaviors? To fill the portfolio, a combination of self-assessments, instructor assessments, and peer-assessments were preferred. For each method, a few conditions were outlined.

For instructor-assessments the objectivity and unbiased attitude of the instructor was stressed, along with using clear rubrics. Additionally, it was required that instructors were properly trained. For self-assessments it was considered essential that students start with practicing this in an early stage to train the reflective nature of this method. For peer-assessments it was also important for students to start practicing this early to avoid bias. Feedback should be provided in a small and safe setting with at least one instructor present.

The next step is to implement these findings in a real training and assessment program to evaluate their effectiveness. As the requirements identified are largely generic, their applicability can be explored across various contexts. Further research is needed to examine the consistency of these requirements when adapted to different aviation maintenance training settings, ideally at an international level.

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