Assessing Student Attitudes Using a Computer-Aided Approach

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BACKGROUND
Included in methods commonly used for assessing vocational training are oral assessments (OAs) since, in addition to assessing knowledge to a depth rarely achieved in other forms of testing, they give unique insight into students' personal attitudes, which are important factors in the workplace. However, OAs require considerable preparation by the assessors, they can be restricted by time and assessor allocation, it is difficult to fully cover the course fairly, and they can put undue stress on the examinees, hence hindering a true expression of their skills and knowledge.

PURPOSE
OAs can give insight into a student's personal attitudes, and the purpose here is to find the relationship between OA observed attitudes and those deduced from the computer-aided assessment.

DESIGN/METHOD
For the computer-aided assessments a scheme based on comparing two statements, followed by fuzzy AHP analysis, was used to determine the student's attitude on such topics as general safety, work area tidiness and cleanliness, care and good use of hand tools and accuracy and testing of equipment. The results from the computer-aided approach were then compared with attitudes on the same topics obtained by oral assessment.

RESULTS
For this work the important result was that there were strong correlations between the OA observed attitudes and the computer-aided assessment derived attitudes of the students. It also became clear however that for safety, the attitude of students (and perhaps workers) is more complicated than just having a 'good' or 'bad' attitude. Social pressure and organisational influence do seem to play a part so influencing or masking the student's true attitudes.

CONCLUSIONS
Satisfactory correlations were found between results of students' attitudes when tested using the OA and computer-aided methods. Further work would need to be done to confirm generalization of substituting OA methods with a computer-aided assessment method.

KEYWORDS
Student attitudes, oral assessments.

Introduction

The major features of competency-based assessment are the emphasis on outcomes, specifically multiple outcomes, each distinctive and separately considered, the belief that these outcomes can and should be specified to the point where they are clear and transparent, and the decoupling of assessment from particular institutions or learning programs (Grant et al., 1979). Also competency-based assessment is criterion-based, evidence-based and participatory. Broadly speaking, there are two types of competency, namely the generic competency and the specific or technical competency. The former includes writing, numeracy, communication, problem solving abilities and social skills (Wood & Lange, 2000). Nordhaug (1998) explains that the latter consists of knowledge of method, process and technique designed to accomplish particular tasks and abilities to use tools and equipment. Important to vocational training is an assessment of a student's attitude. A student's attitude is important to both learning ability and in the workplace as attitude predisposes a student's mind. Students who are positive about learning, like education, feel safe physically and emotionally, and when nurtured, learn more readily and deeply than those who do not. This can be extended to being positive in the workplace where a positive mind will think and act for the better when confronted with problems concerning safety, tidiness and looking after equipment and tools.

Included in methods commonly used for assessing vocational training are oral assessments (OAs) since they give unique insight into students' personal attitudes, which are important factors in the workplace. However, OAs require considerable preparation by the assessors, they can be restricted by time and assessor allocation, and it is difficult to fully cover the course fairly. There is also evidence that OAs are thought of by students as more difficult than other forms of examination, leading to more apprehension before and during the examination than with written examinations (Sarid, Anson, & Bentov, 2005). Even with these shortcomings, OAs remain popular as an assessment method in vocational training as they provide insights into a candidate's personal attitudes not found in other assessment methods.

It is recognized that computer-aided tests have merits and problems. They are efficient and straightforward to run, and they give an assessment environment which is less stressful than OA, but, they have a major disadvantage in that students will on occasions guess answers when multiple-choice questions (MCQs) are used. For the computer-aided assessments in this work, there is no need for a student to guess, although it is recognised that a subjective response is involved. A scheme based on comparing two statements, and using a nine-point rating to express the relative importance between two chosen criteria, followed by fuzzy AHP analysis is used to determine a student's attitude on the topics general safety, work area tidiness and cleanliness, care and good use of hand tools and accuracy and testing of equipment. For example, to measure a student's attitude towards general safety, five aspects isolated by Williamson et al. (1997) were examined. The AHP is a useful method for solving complex decision-making problems involving subjective judgment (Saaty, 1990), although it does not fully represent human perceptions and judgments. Fuzzy set theory (Buckley, 1985) does resemble human reasoning, and, by incorporating fuzzy set theory into AHP, the resulting fuzzy AHP enables a more accurate description of the multiple-attribute decision-making process (Bozbura, Beskese, & Kahraman, 2007).

The computer-aided assessment package was written using the Java programming language (Liang, 2009). There are many already-written application-specific Java classes which are compatible and reusable for MCQs type testing and these object-orientated components can be developed using inexpensive, professional-quality Java development environments.

In summary, the aim of this study is to develop a computer-aided method of accessing students' attitudes for general safety, work area tidiness and cleanliness, care and good use of hand tools, and accuracy and testing of equipment, and, to compare the results with those obtained using oral assessment.

Methods and Procedures

Workshop course

The workshop course used in this work was that provided by the Australian TAFE system, set at Certificate III level in Engineering and entitled “Use tools for precision work”. Included in the course was, safety, responsibility, marking out, scrappers and scraping, key fitting, drills and drilling, the reaming process, dowelling, threading and thread repair, lapping and burnishing, and broaching.

Examinees

There were 183 students taking the course, in three cohorts (N_{c1} = 59, N_{c2} = 63, N_{c3} = 61) with personal characteristics summarized in Table 1. It was important to familiarize all students beforehand with the electronic assessment package and with the OA in an effort to eliminate bias.

Table 1: Personal characteristics

Characteristic	
Average age	17.05 years
Percentage female	0%
Major	Mechanical Eng. 78% Automotive Eng. 22%
Experience in workshop	
- TAFE Certificate I	93%
- TAFE Certificate II	86%
- None	2%
Preferred learning style(s)	
- Reading instructions	18%
- Instructions for instructor	37%
- Demonstration by instructor	45%
Likes to work in groups	53%

Electronic Assessment Package

The electronic assessment package was written using the Java programming language. A GUI (Graphical User Interface) was designed for the examinees consisting of a series of JFrames on which was placed panels, buttons, text fields, labels, checkboxes, images and animations as appropriate. The package was fully interactive and designed to be user friendly. The GUI was networked to a central server where data could be deposited, stored and retrieved for further analysis.

To include assessors’ perceptions of students’ personalities and attitudes, the fuzzy AHP approach was used. The essential steps of the application of AHP is first to decompose an area of interest, for example safety, into problems that can be easily comprehended and evaluated, secondly to determine the priorities of the elements in each area, and thirdly to synthesize the priorities to determine the overall priorities of the decision alternatives. After constructing a hierarchy of problems for each area of interest, the student is asked to compare the elements in a given area on a pair-wise basis to estimate relative importance. The scale used here, as shown on Figure 1, is a nine-point scale which shows the students’ judgments among the options as equally, moderately, strongly, very strongly or extremely preferred.

The AHP method (Saaty, 1990) indicates that the eigenvector corresponding to the largest eigenvalue of the pair-wise comparisons matrix provides the relative priorities of the factors and preserves ordinal preferences among the alternatives. This means that if an alternative is preferred to another, its eigenvector component is larger than that of the other.

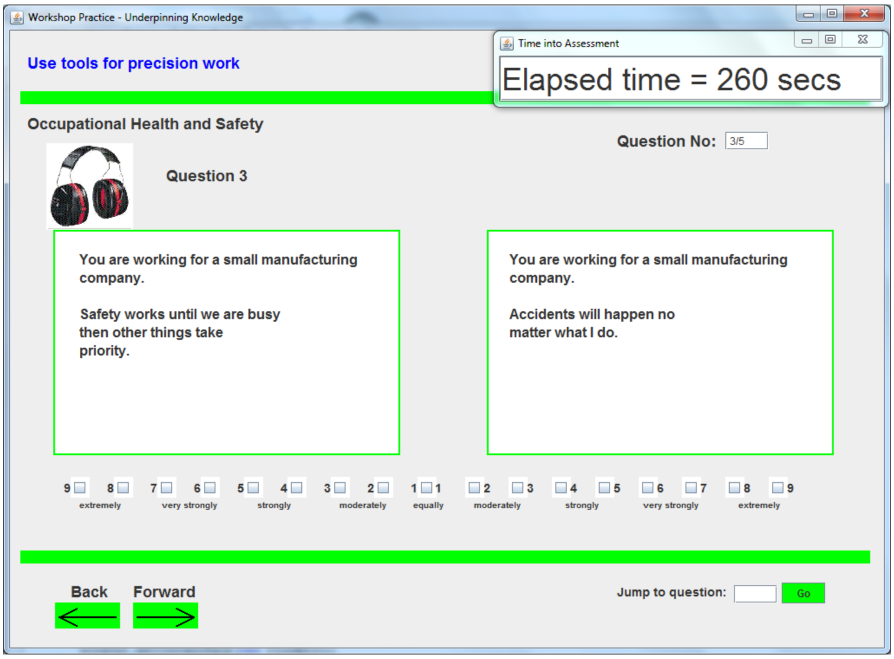


Figure 1: Example of JFrame showing 9-point rating scale

A vector of weights obtained from the pair-wise comparisons matrix reflects the relative importance of the various factors.

So, assuming there are N number of decision elements, denoted as (E_1, ..., E_i, ... E_n), the judgment matrix would be $A = [a_{ij}]$, in which a_{ij} represents the relative importance of E_i and E_j. Then, by using the row vector average normalization, the weight of E_i is calculated as,

$$w_i = \frac{\left(\prod_{j=1}^{n} a_{ij}\right)^{\frac{1}{n}}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}\right)^{\frac{1}{n}}} \qquad i, j = 1, 2, \ldots, n \tag{1}$$

where w_i denote the weight of the i^{th} decision element, and weight vector $w = (w_i)$, $i = 1, ..., n$. The uncertainty found in human perceptions and judgments is captured using triangular fuzzy members, $\tilde{1}$ to $\tilde{9}$ to represent subjective pair-wise student attitudes. A fuzzy number is a special fuzzy set $F = \left(x, \mu_F(x)\right), x \in R$ where $\mu_F(x)$ is a continuous mapping from the real line R to the closed interval [0, 1]. A triangular fuzzy number denoted as $\widetilde{M} = (a, b, c)$ where $a \leq b \leq c$ has a triangular-type membership function. Here a and c stand for the smallest possible value and the largest possible value of the support of $\widetilde{M}$, respectively, and b is the most promising value of $\widetilde{M}$ that describes a fuzzy event (Kahraman et al., 2003). In fuzzy AHP, triangular numbers are utilized to improve the scaling scheme in the judgment matrices (Kaufmann & Gupta, 1991), and interval arithmetic is used to solve the fuzzy eigenvector (Chen & Mon, 1994). The full fuzzy AHP algorithm used in this work is reported in Adair & Jaeger (2011).

Assessing Students' Attitudes

Measuring an attitude is a difficult task as any attitude is a construct which may be uni-dimensional or multidimensional. The existence of an attitude is inferred by a person's words or behaviour. Kerlinger (1986) defines an attitude as an organised predisposition to think, feel, perceive and behave toward a referent or cognitive object. Krathwohl, Bloom and Masia (1964) advanced a five level taxonomy for framing attitudinal objectives which is useful here in guiding the measurement decisions. Of the five levels, emphasis is placed on investigating an individual student's level of responsiveness, acceptance of value and level of internalization of values. During the OA sessions these levels were ascertained by listening to and observation of the student with a judgment made by each of the examiners; for the computer-aided assessment a scheme based on comparing two statements, as shown on Figure 1, followed by fuzzy AHP analysis to measure the student's attitude. For example, to measure a student's attitude towards general safety, the five aspects isolated by Williamson et al. (1997) were examined. The first was *Personal motivation for safe behaviour*, as it comprises items which would promote safer behaviour. The second was *Positive safety practice*, because it contains items which reflect safety activity in the work place. The third aspect of general safety assessed was *Risk justification*, since it is a collection of items about the instances when and the reasons why the student may have worked unsafely or took risks. A fourth item was interpreted as *Fatalism* because it contains items which focus on lack of control over being safe. Lastly, the fifth item was interpreted as *Optimism* as this reflects a favourable view of personal accident risk. As an example, some of the statements used for comparison within *Fatalism* are listed in Table 2, and as there are five statements this results in 10 combinations to be answered by students. Details of the questions asked about the other four aspects of general safety are listed by Williamson et al. (1997).

Table 2 Statements for *Fatalism* used for comparison in the computer-aided assessments

Statements	Increasing importance ⟵ Increasing importance ⟶	Statements
	Fatalism	
Safety works until we are busy then other things take priority	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	If I worried about safety all the time I would not get my job done
Safety works until we are busy then other things take priority	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	I cannot avoid taking risks in my job
. .	. .	. .
I cannot avoid taking risks in my job	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	I can't do anything to improve safety in my workplace
Accidents will happen no matter what I do	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	I can't do anything to improve safety in my workplace

Results

To compare students' attitudes obtained by the computer-aided and OA methods of assessments, the results associated with knowledge of safety and its sub-categories first are reported here. The assessors, during each OA, were asked to rank the students attitudes to general safety and its sub-categories. The assessors had to use exactly the same statements for ranking as those found in the computer-aided assessment, but they were at liberty to discuss safety in any way they wished with the students. The rankings were correlated with the rankings found using the fuzzy AHP algorithm (Adair & Jaeger, 2011) for each student. The combined correlations for general safety and the sub-categories may be expressed in terms of the correlations, standard deviations and differences between the subgroup means and the means of the total group as (Dunlap, 1937),

$$r_{xy} = [m\sigma_{x_m}\sigma_{y_m}r_{x_m y_m} + n\sigma_{x_n}\sigma_{y_n}r_{x_n y_n} + \ ... + k\sigma_{x_k}\sigma_{y_k}r_{x_k y_k}$$
$$+m\delta_m\Delta_m + n\delta_n\Delta_n + \ ... + k\delta_k\Delta_k] \div [m(\sigma_{x_m}^2 + \delta_m^2)$$
$$+n(\sigma_{x_n}^2 + \delta_n^2) + \ ... + k(\sigma_{x_k}^2 + \delta_k^2)]^{1/2}[m(\sigma_{y_m}^2 + \Delta_m^2) \quad (2)$$
$$+n(\sigma_{y_n}^2 + \Delta_n^2) + \ ... + k(\sigma_{y_k}^2 + \Delta_k^2)]^{1/2}$$

where m, n, ..., k are the numbers in the groups to be combined and also act as the labels for the groups, δ and Δ are deviations of x and y values from the means of the total group respectively. The combined correlations for general safety and its four sub-categories are given in Table 3.

Table 3 Correlations of the student attitudes assessments for General Safety

Student Cohorts	Correlations between Computer-aided and OA Assessment Methods					
	Personal Motivation	Positive Safety Practice	Risk Justification	Fatalism	Optimism	General Safety
C_1 (N_{c1} = 59)	0.9541	0.9436	0.9012	0.9002	0.8601	0.8913
C_2 (N_{c2} = 63)	0.9345	0.9213	0.8977	0.8956	0.9159	0.9057
C_3 (N_{c3} = 61)	0.9312	0.9124	0.9023	0.9134	0.9278	0.9223
Total (N_T = 183)	0.9123	0.9387	0.8763	0.8876	0.9366	0.9025

Generally the correlations were found to be acceptable, in the range $0.9 < r_{xy} < 0.95$ although the results for the total cohort were slightly outside this range in the sub-categories *Risk Justification* and *Fatalism*.

Similar sub-categories were isolated for the topics

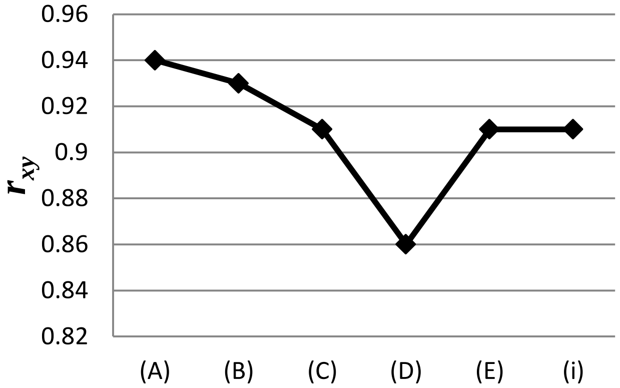
(i) work area tidiness and cleanliness;
(ii) care and good use of hand tools; and,
(iii) accuracy and listing of equipment.

The sub-categories for each of these topics are listed in Table 4.

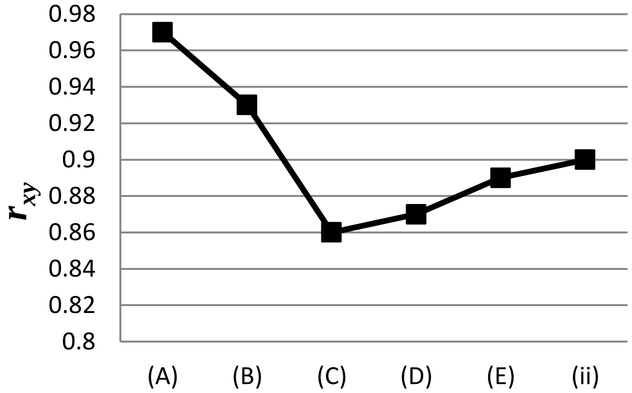
Table 4 Sub-categories for topics

	Sub-categories				
Topic	**(A)**	**(B)**	**(C)**	**(D)**	**(E)**
(i)	Personal Motivation workshop tidiness & cleanliness	Positive on workshop tidiness & cleanliness	Risk justification of workshop being untidy and unclean	Fatalism concerning workshop tidiness and cleanliness	Optimism on workshop tidiness and cleanliness
(ii)	Personal Motivation on having hand tools properly cared for and their good use	Positive on care and good use of hand tools	Risk justification of not taking care of hand tools	Fatalism about lack of control about hand tools' good condition/use	Optimism on the good condition and use of hand tools
(iii)	Personal Motivation about accuracy & testing of equipment	Positive on accuracy & testing of equipment	Risk justification of not worrying about accuracy and testing of equipment	Fatalism of about lack of control over equipment accuracy testing	Optimism on the accuracy & testing of equipment

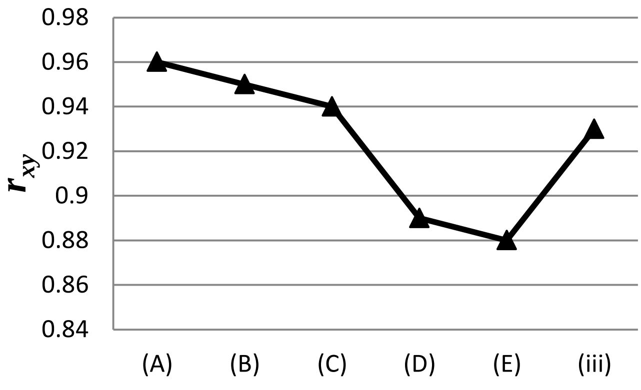
A summary of the correlations for the above categories is given on Figure 2 for the total student cohort (N_T = 183).



(i) Work area tidiness and cleanliness



(ii) Care and good use of hand tools



(iii) Accuracy and listing of equipment

Figure 2: Correlations obtained for each of the sub-categories and topics listed in Table 4.

It can be seen that the correlations are satisfactory except for the categories *Risk* and *Fatalism,* where the correlations were less than 0.9.

Discussion

The five sub-categories are a combination of students' general safety attitudes and perceptions of real workplace situations. The best correlations between the OA and electronic assessments, as seen from Table 3, was for *Personal motivation for safe behaviour,* which indicates how the students perceive deficiencies in the workplace which prevent them from acting in a safe manner. The category related to this, that is, *Risk justification*, which looks at cases where unsafe behaviour actually occurred, did not have as strong correlations, although they are thought acceptable. Reasonable correlations were also found for the sub-category *Positive safety practice*, which is concerned with perceptions of safety in the workplace in relation to the role and commitment of management to safety. The correlation for the total cohort was the highest of the five sub-categories. The last two factors, *Fatalism* and *Optimism* are about the students' attitudes and beliefs about safety, with the former concerned with the importance and controllability of safety and the latter with how a student believes that their level of personal risk is favourable. *Fatalism* generally gave the worst correlations between OAs and the computer-aided assessment. The correlations were still thought of as acceptable, but perhaps this category needs further investigation as it was found (Williamson et al., 1997) that this sub-category appears to be resistant to change due to experience. It is possible that this is a more enduring personal characteristic which contributes to safety change, but which may not be very amenable to change.

It was noted both for the OA and computer-aided results that the students displayed a strong skewedness in the direction of good safety. That is, a large majority of the students show attitudes and perceptions that were in favour of high safety standards. Some did display less knowledge than they should, but certainly in the areas of who is responsible for safety, safety as a priority, and how they should act in the workplace, the responses were satisfactory. As the statements in the computer-aided testing became more based on reality, it was noticeable that the skewedness reduced. This observation would need further investigation to discern if the more abstract statements were answered in a strongly positive fashion due to peer pressure or what is socially accepted rather than what the students actually believe.

The results shown on Figure 2 follow a similar trend to that demonstrated by the safety analysis. It was very noticeable that correlations between the OAs and the computer-aided assessments were weaker for *Risk* and *Fatalism*. Again it must be said that further work will need to be done to ensure that computer-aided assessments are indeed a good substitute for these two important sub-categories.

For this work the important result was that there were strong correlations between the OA observed attitudes and the computer-aided assessment derived attitudes of the students. It also became clear, however, that for safety, the attitude of students (and perhaps workers) is more complicated than just having a 'good' or 'bad' attitude. Social pressure or organisational influence do seem to play a part so influencing or masking the student's true attitudes.

Some caution should of course be exercised with the above correlations. For example, it is clear that a clever student could work out what kind of attitudes the examiners would approve of and those they would not approve of. Therefore, although much development was carried out with students not being tested to try to form questions which at least disguised to some extent what the desired answers would be, it is recognised that this weakness needs more investigation. Also, the difference between both assessment methods could possibly be explained by less pressure for desired answers. This pressure would be found more in the oral assessment as follow up questions would be used if a student was not clear or showed doubt and indecision, although if a good grade is the prize this may not make that much difference. Again, it is recognised that some further work is necessary here to see if pressure for desired answers is a significant factor.

Conclusions

Satisfactory correlations were found between results for students' attitudes when tested using the oral assessment (OA) method and the computer-aided method incorporating fuzzy AHP, except for the sub-categories *Risk* and *Fatalism*. While the correlations between OAs and computer-aided assessment were greater than 0.85 there is some hesitation in stating that computer-aided assessments are fully adequate to the task of replacing OAs to judge student attitude. Further investigations are still needed. The effect of pressure for desired answers may be a further factor as is the need to better disguise what attitudes a given examiner is looking for.

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