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Technology student learning preferences and the design of flexible learning programs

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Abstract. The learning preferences of three hundred and thirty eight technology students enrolled in sub-degree programs at an Australian institution of Technical and Further Education were tested using the *Canfield Learning Styles Inventory* (*CLSI*). The results have been interpreted in a learning preferences framework and provide supportive evidence for the preferences factors of print-nonprint, collaborative, dependent, and autonomous learning identified by Sadler-Smith & Riding (1999). Although the research focussed on learning preferences the analysis also indicated support for the Wholist-Analytic cognitive style proposed by Riding & Cheema (1991). Gender differences were shown for the Interest subscales of the *CLSI*. Age-group differences were shown for several Conditions of Learning and Modes of Learning subscales.

Implications for the design of training programs, and the skills that may need to be developed in technology learners to enable effective use of flexible delivery, are also discussed.

Keywords: flexible delivery, flexible learning, Field dependent-Field independent, learning preferences, learning styles, technology students, Wholist/Analytic

Introduction

In a context of increasing interest in the provision of education and training through flexible delivery in situated learning environments, the need for learner information that will assist in the effective design and delivery of workplace programs has become important. Exploring the concepts of situated learning and cognitive apprenticeship, Farmer et al. (1992), consistent with Dreyfus' (1982) five stages of skill development, suggest that experts provide guidance and assistance (scaffolds) for early learning by novices, gradually decreasing that assistance as learners construct their own knowledge base. What those scaffolds should be, and how they can be delivered to learners in technical training environments demands some consideration. An important step in the process of identifying those needs and processes is the identification of the learning preferences, and learning context preferences, of technical learners. The present research has been designed to provide information on the learning preferences of sub-degree level technology students,

with a view to assisting in the design and delivery of flexible learning programs for this level of vocational student.

The identification of the learning preferences of the target group of learners is not only a matter of implementing the 'matching-model', where the design of the instruction and its methodologies is necessarily geared to the averaged characteristics of the group. While matching instructional methods to learning preferences provides one form of response to learner-centred flexible delivery, as Sadler-Smith (1996) has pointed out, this may not be cost-effective in a context of variations in preferences within a group of learners. He advocates an approach, similar to the current author, that also encourages learners to undertake activities beyond those preferences, and to develop learners to enable engagement with a broader set of instructional methods and materials. The analysis of learning preferences enables the identification of areas of learning skill development that may be required in the learner group to enable effective engagement with the learning program.

Curry (1983), in her 'onion model', has suggested that preferences are amenable to change and development to suit different learning demands. White (1997), working with distance education students has shown, for example, that experienced distance learners attribute their success to an understanding of their own metacognition, and she has further shown that student learning preferences and strategies can be developed to provide greater confidence with independent learning. A similar observation was made by Boote (1998) when she suggested that learner success with flexible delivery is enhanced by knowledge of metacognition, but she also lamented that these skills are not addressed in the preparation of vocational learners. Evidence to support the notion that learners can be trained to develop versatility in learning styles and preferences has also been provided in research by Hayes & Allinson (1998). The view that learners can be trained to develop versatility is also held by Sternberg and Grigorenko (1997). The importance of learner knowledge of personal styles and preferences has been shown by Vermunt (1995) and McGregor & Quam (1996) to be an important factor in adjusting and developing learning behaviour to achieve enhanced outcomes.

Drawing attention to the number of conceptualisations of the term 'learning styles', Curry (1983) organised the various models into three layers, likening them to the layers of an onion. She suggested that the outermost layer, of 'instructional preference', refers to the individual's choice of environment within which they learn. Her expectation was that this layer was most likely to change, and be influenced by what is being learned and the learning context. The second layer is the 'information processing style' and, while not directly interacting with the learning environment, is still capable of modification through learning experience and the development of learning

strategies. The innermost layer of Curry's model is 'cognitive personality style' which she saw as an underlying and relatively stable permanent personality characteristic. Sadler-Smith (1996) used Curry's (1983) onion ring concept to further extend the nomenclature to include 'learning strategies' and 'cognitive strategy'. The former, according to Sadler-Smith (1996), is a plan of action adopted in learning through study or experience; while the latter he saw as a plan of action adopted in organising and processing information. The current study has focussed on learning preferences to enable the research information to also be used to develop strategies to modify learner preferences where that is useful to enable effective engagement in flexible learning.

Investigations of student learning preferences have shown that gender, age-group, and discipline of study are variables that influence the results of research. For example, Brainard & Ommen (1977) have shown that females have a greater preference for the qualitative and people-oriented disciplines, while males had a greater preference for numeric and inanimate content in learning. Similarly, Heikkinen et al. (1985) have also shown a preference among males for content involving numeric and inanimate concepts, while females preferred qualitative content and content involving people. Males also preferred a competitive learning environment, and instructors who are authoritative, while females preferred a learning context that is well organised and provided clear instruction to students. Differences between genders were also shown among vocational students by Smith & Lindner (1986), with males preferring numeric and inanimate content, females preferring qualitative and people-oriented content; and with females showing a stronger preference than males for learning through reading.

Research on the relationship between age and learning preferences has shown inconsistent results. A higher preference among younger students for learning in affiliative environments, where importance is assigned to relationships between peers and the instructor, has been shown by Ommen et al. (1979). A preference for course and classroom structure has been shown by Holland (1980) and Verner & Davidson (1982) to be stronger among younger students. Consistent with that finding, McCollum et al. (1995) have shown younger students to be more resistant than older students to change towards taking more responsibility for their own learning in less structured learning environments. On the other hand, Smith and Lindner (1986) showed that, among vocational students, it was older learners who preferred classroom and program structure.

Significant learning preference differences between program groups at college level have been shown by Canfield (1980). Education and criminal justice students had a preference for a well-organised course with clear

expectations. Business and data-processing students were characterised by a low interest in content pertaining to people; and art history students showed preference for material involving inanimate objects, for delivery that included strong affiliation with the instructor, and for visual presentation of material. Smith & Lindner (1986) found that the learning preferences of different vocational education program groups were distinctive, and tended to reflect what an intuitive expectation of the group would predict. For example, Child Care students had preferences for working with qualitative information and with people, while apprentices in Plumbing, Sheetmetal and Electrical Mechanics preferred working with inanimate objects, and learning through direct experience. Using Schmeck's (1983) Deep and Elaborative Processing scales and working at the level of learning styles, rather than preferences, Westman (1993) has shown that learning styles are content related, and may be influenced by the content being studied. Also working at the level of learning styles, using Kolb's (1984) *Learning Style Inventory*, Reading-Brown & Hayden (1989) have shown that students in technical training programs display a learning style characterised by passive observation and reflection, combined with direct experience.

An attempt to integrate the many conceptualisations of learning style has been made by Riding & Cheema (1991), in their development of a two dimensional model of cognitive style. In that model, one dimension is conceptualised as Wholist-Analytic, and the other as Verbaliser-Imager. Riding and Cheema (1991) and Riding & Sadler-Smith (1992) have suggested that the Field-dependence/Field-independence dimension (Witkin et al., 1977) is a label used "within the Wholist-Analytic Cognitive Style family" (Riding & Sadler-Smith, 1992: 324), with Field-dependents lying within the Wholist category. In an attempt to develop predictions to assist the instructional design and delivery of learning programs to meet the needs of different groups of learners, or individuals Riding & Sadler-Smith (1992) and Sadler-Smith & Riding (1999) have also begun to investigate the relationship between cognitive style and instructional preference. In a factor analytic study of the instructional preferences of business studies students, Sadler-Smith and Riding (1999) have identified three distinct categories of preference for instructional method:

- collaborative methods (role plays, discussion, games);
- dependent methods (lectures, tutorials);
- autonomous methods (independent learning, computer assisted learning.

The development of a learner typology based on the *Canfield Learning Styles Inventory* (*CLSI*) (Canfield, 1980) has been attempted by Gruber & Carriuolo (1991). Although it is named as a learning styles inventory, the *CLSI* in fact assesses learning preferences, and provides scores on sixteen

subscales of learning preference. Gruber and Carriuolo have identified a two factor structure for their *CLSI* data, indicating a Conceptual-Applied factor and a Social-Independent learning factor. It is possible to reinterpret the Gruber and Carriuolo Conceptual-Applied style factor as a preference factor similar to the print–non-print preference factor shown by Sadler-Smith & Riding (1999). However, the factor identified by Gruber and Carriuolo showed high loading for the subscales relating to Qualitative content and Inanimate content. A broader interpretation of the factor in preferences terms may be to see it as a Verbal-Non-Verbal factor. The Social-Independent factor, conceptualised as a style by Gruber and Carriuolo can also be interpreted in Sadler-Smith & Riding's (1999) terms as a preference factor relating to collaborative-autonomous learning.

An examination of the learning preferences of the technology students in the current sample forms a major component of the current research. Gender and age-group are examined as independent variables in the research, while area of study is controlled by sampling only students enrolled in similar sub-degree level technology programs. Additionally, the study will re-examine the factor structure shown for the *CLSI* by Gruber & Carriuolo (1991), and derived from data provided by US community college students. The factor structure derived from that sample may not be replicated with the quite different sample of Australian vocational learners.

Data collection

A sample of 338 technology students was tested for their learning preferences using the Canfield Learning Styles Inventory (*CLSI*). Students were enrolled in an Australian institution of Technical and Further Education (TAFE). A TAFE institute in Australia enrols students at post-secondary level for study at the sub-degree level, in technology, business, health studies, the arts, and in trade programs. The students in the current research were all studying sub-degree technology programs in engineering, laboratory technology or electronics, where instruction is typified by some classroom instruction, and an emphasis on practical training in laboratories, workplaces, and simulated workplaces. The sample of 338 technology students comprised 212 males and 126 females. The mean age of the males was 24.63 years, and that of the females was 26.52 years. There were 93 males and 50 females aged under 21 years, and 119 males and 76 females aged 21 or over.

The *CLSI* is a paper and pencil test consisting of thirty items, yielding scores on sixteen subscales relating to Conditions of Learning, Interests, and Mode of Learning. Respondents rank each of four statements provided in association with each of the thirty items, such that ipsative data is provided by

the *CLSI*. There is some controversy over the statistical treatment of ipsative data, but recent work by Baron (1996), Bartram (1996) and Cattell & Brennan (1994) indicates that statistical analysis and factorability is largely unaffected where the number of variables and the data matrix are large enough. Bartram (1996) and Cattell & Brennan (1994) suggest the number of variables must exceed about ten. The current study provides a sixteen variables by 338 subjects matrix.

The *CLSI* provides scores on the following sixteen subscales:

I. Conditions of learning subscales

The first eight scores reflect common concerns for the dynamics of the situation in which learning occurs. They cover eight score areas:

Peer: Working in student teams; good relations with other students; having student friends; etc.

Organisation: Course work logically and clearly organised: meaningful assignments and sequence of activities.

Goal Setting: Setting one's own objectives; using feedback to modify goals or procedures; making one's own decisions on objectives.

Competition: Desiring comparison with others; needing to know how one is going in relation to others.

Instructor: Knowing the instructor personally; having a mutual understanding; liking one another.

Detail: Specific information on assignments, requirements, rules etc.

Independence: Working alone and independently; determining one's own study plan; doing things for oneself.

Authority: Desiring classroom discipline and maintenance of order; having informed and knowledgeable instructors.

II. Interest subscales

Major areas of interest:

Numeric: Working with numbers and logic; computing; solving mathematical problems.

Qualitative: Working with words or language; writing; editing; talking.

Inanimate: Working with things; building, repairing, designing, operating.

People: Working with people; interviewing; counselling; selling; helping.

III. Mode of learning subscales

General modality through which learning is preferred.

Listening: Hearing information; lectures, tapes, speeches etc.

Reading: Examining the written word; reading texts, pamphlets etc.

Iconic: Viewing illustrations; movies; videos; slides; pictures; graphs etc.

Direct Experience: Handling or performing; shop, laboratory, field trips, practical exercises etc.

Results

Means scores and standard deviations were calculated for each subscale for the group of technology students, and by gender and by age-group. Table 1 shows the mean and standard deviation for the complete sample of technology students. In Table 1, the subscales are ranked from most preferred to least preferred by mean, within each of the Conditions of Learning, Interests and Mode of Learning focuses of the *CLSI*. Since the data from the *CLSI* are ranked, the most preferred subscale is that with the lowest mean, and so on.

Differences between genders and age-groups were identified through a two-way analysis of variance (ANOVA) computed on each subscale. Table 2 shows the means and standard deviations by gender and by age-group on each of the subscales for which a significant difference ($p < 0.01$) was identified. Since the research analysis involves multiple statistical testing on the same sample, following Harper and Kember (1986), Richardson et al. (1999) and Smith and Smith (1999), a significance level of 0.01 was adopted as a more stringent criterion to overcome the higher probability of interpretative error. Table 2 also shows the F-ratio resulting from the ANOVAs.

A principal components factor analysis was conducted, with the most interpretable result being a three factor extraction after Varimax rotation. Results of that factor analysis are shown as Table 3. Only subscale loadings greater than 0.4 have been considered in factor interpretation, and to be considered as loading distinctively on a factor, a criterion was set that subscale loadings had to be at least 0.15 greater than the loading of that subscale on another factor.

Factor scores were also generated for each factor, by gender and by age-group, using the regression method. Those means and standard deviations of the factor scores are shown as Table 4, together with the results of the two-way ANOVA calculated on the factor scores for each factor.

Table 1. CLSI subscale means and standard deviations. Subscales ranked from highest to lowest preference within headings

CLSI subscale	Mean	SD
Conditions of learning		
Organisation	11.78	3.12
Detail	12.16	3.47
Instructor	14.05	3.39
Goal	15.09	3.39
Peer	15.64	3.34
Authority	16.53	3.64
Independence	17.01	3.66
Competition	17.40	3.00
Interests		
Inanimate	12.80	3.92
People	15.31	4.01
Numeric	15.62	4.03
Qualitative	16.13	4.03
Mode of learning		
Direct experience	12.95	4.52
Listening	14.36	3.80
Iconic	15.12	3.96
Reading	17.50	4.18

Discussion

Subscales analysis

The ranking of the Conditions of Learning subscales indicates a strong preference for learning in an environment where the learning program is well-organised and the details of the program and its requirements are known in advance. These findings are consistent with Reading-Brown and Hayden's (1989) that technical students at the American college level were characterised by a passive learning approach where the students were more inclined to learn in a context of clarity and guidance provided by the instructor and the learning program. Also consistent with Reading-Brown and Hayden is the finding in the present study that the technology students prefer to learn through direct experience with the equipment or processes being learned. Additionally, the technology students in the current investiga-

Table 2. Means by gender by age-group for *CLSI* subscales showing significant within-group differences

Subscale	Males		Females		Gender	Age-group
	Younger	Older	Younger	Older	(*F*-ratio)	(*F*-ratio)
Organisation	12.38	11.40	12.40	11.25	0.05	9.33**
Detail	12.61	11.94	11.82	12.17	0.24	0.61
Instructor	13.18	14.81	13.44	14.32	0.24	13.54**
Goal setting	15.11	15.14	15.26	14.88	0.06	0.10
Peer	14.83	16.42	14.60	16.10	0.61	18.70**
Authority	16.90	15.87	17.50	16.46	2.11	6.73**
Independence	16.67	17.42	16.72	17.00	0.30	2.08
Competition	17.38	17.12	17.38	17.88	1.78	0.00
Inanimate	11.14	11.53	15.58	14.97	75.96**	0.00
People	17.23	15.33	13.76	13.96	25.29**	6.67**
Numeric	14.68	15.18	16.10	17.13	14.66**	2.45
Qualitative	16.90	17.89	14.04	13.80	80.53**	1.90
Direct experience	12.57	12.88	12.70	13.68	1.06	1.26
Listening	15.62	13.42	14.66	14.08	0.00	15.56**
Iconic[a]	13.38	16.15	15.62	15.30	0.99	15.29**
Reading	18.35	17.59	16.78	16.80	5.56	1.07

** Denotes significance beyond the 0.01 level.

[a] Denotes an interaction effect between gender and age-group on that subscale.

Degrees of freedom are 1,334 for each analysis.

tion were characterised by a preference for learning in a social environment where they were able to establish a relationship with their instructor and with their peers. Within that context, they also show a preference for determining their own learning objectives, and using feedback to modify those goals. Consistent with their preference for a social learning environment, the students showed a low preference for independent learning, where they would work alone and set their own study plans.

The higher preferences assigned by the students to subscales such as Organisation, Detail, Instructor and Peer suggest the possibility of a field dependent (Witkin et al., 1977) style among technology students. Witkin et al. (1977) have assigned a number of characteristics to field-dependents which are consistent with the findings from the present study. They have asserted that field-dependents are more likely to use a learning program in the way it is constructed by the instructor, rather than restructuring it in a way that may have more meaning for themselves; that field-dependents have a social orientation and like to learn through being with people; are more likely to require

Table 3. Three factor structure of the 16 *CLSI* subscales for all technology students (n = 338)

	Factors (total variance 41.9%)		
	Factor 1 (verbal)	Factor 2 (collaborative)	Factor 3 (self-directed)
Variance accounted for	15.5%	14.8%	11.6%
Eigenvalue	2.49	2.36	1.85
CLSI subscales			
Peer	−0.02	**0.65**	0.22
Organisation	−0.01	−0.53	0.40
Goal setting	0.06	−0.14	**−0.81**
Competition	−0.07	−0.02	0.21
Instructor	−0.08	**0.73**	0.15
Detail	−0.07	**−0.61**	0.27
Independence	0.11	0.04	**−0.83**
Authority	0.03	−0.08	**0.44**
Number	−0.35	−0.20	0.12
Qualitative	**0.63**	−0.21	−0.11
Inanimate	**−0.76**	−0.02	0.06
People	0.55	0.42	−0.07
Listening	0.40	−0.03	0.40
Reading	**0.55**	−0.39	−0.06
Iconic	−0.21	0.37	−0.23
Direct experience	**−0.65**	0.07	−0.06

NB: Values in bold print represent factor loadings that contribute distinctively to the factor.

Table 4. Factor score means and two-way ANOVA results – gender by age-group

	Males		Females		Gender	Age-group
Subscale	Younger	Older	Younger	Older	(F-ratio)	(F-ratio)
Factor 1	0.48	0.18	−0.48	−0.55	64.44**	4.66
Factor 2	−0.21	0.21	−0.21	0.07	0.59	11.64**
Factor 3	0.14	−0.16	0.06	0.04	0.64	3.28

** Denotes significance beyond the 0.01 level.
No significant gender by age-group interactions.
Degrees of freedom are 1,336 for each analysis.

externally defined goals and reinforcement; need learning to be organised and the organisation to be known in advance; and are more interested in the concrete than in the abstract or theoretical. The technology students in the current sample have shown a higher preference for goal setting than may be predicted of them as field-dependents, but whether the students like to set those goals within the structure provided, or set goals that go beyond that structure is unclear from the results. Given the high preferences for organisation and detail, and the relatively proscribed nature of the curriculum, it is reasonable to hypothesise that further investigation of the goal setting preference may show that their liking for goal setting is restricted to the curriculum and learning context provided.

Sadler-Smith & Riding (1999), using the Wholist-Analytic model have suggested that the characteristics of field-dependence are contained within their Wholist conceptualisation, and have identified a highly significant preference among Wholists for non print-based media of instruction, and a stronger preference among Wholists for collaborative learning methods. These findings are consistent with Riding's (1991) suggestion that Wholists are sociable and socially dependent. The results from the current investigation are consistent with a conclusion that the sample of technology learners are Wholists in cognitive style, with the Interests subscales showing highest preferences for working in the concrete with inanimate objects, and for content involving people. Additionally, the students have shown a strong preference for non print-based media, ranking reading very low, and direct experience very high.

The differences between the genders are only important in the Interest subscales. The findings of the present study in the Interest subscales are consistent with Brainard & Ommen (1977) and Heikkinen et al. (1985) that males prefer working with inanimate objects and numeric content, while females preferences were higher for qualitative learning and content about people. Not confirmed by the present investigation was the Heikkinen et al. (1985) finding that males prefer a competitive learning environment and authoritative instructor, while females prefer a well organised learning environment with clear detail provided in advance. Indeed, the present study showed that both genders among the technology students sampled had a high preference for organisation and detail, and low preference for the competitive environment and a relatively low preference for authoritative instructors.

Differences between age-groups are concentrated in the Conditions of Learning and Modes of Learning subscales. Among the Interest subscales, only the People susbscale showed any difference, with the older students showing a higher preference than the younger students. In the Conditions of Learning subscales, however, older students showed a significantly higher

preference for the Organisation and the Authority subscales, with younger students indicating significantly higher preferences for the Peer and Authority subscales. These results indicate that older students are more inclined towards well organised instruction where the instructor provides authoritative instruction, while the younger students are more inclined towards a social context for learning, where they establish good relationships with their peers and their instructor. The significantly higher preference among older students for the Listening mode, together with the findings in the Conditions subscales, suggests that these students may feel more comfortable in a traditional instructor-led learning environment. The higher preference for the Iconic subscale among the younger students is confined to the males, as shown by the interaction effect. These results suggest that younger students in the current study are more amenable to a learning environment which is characterised by discussion, with the younger males also showing higher preference for observation as a form of learning. These findings are consistent with the Ommen et al. (1979) identification of younger students as more affiliative than older students, with a preference for learning in contexts that provided greater social interaction. Contrary findings by Holland (1980) and Verner & Davidson (1982), though, have shown older students to have less need than younger students for course and classroom structure. The Ommen et al. (1979) study also showed older students to have a higher preference for Listening.

The subscale analysis also provides some evidence that the factors identified by Sadler-Smith & Riding (1999) in their work at the preferences level may be demonstrable in the current investigation as well. The subscale rankings indicate that there may be identifiable factors associated with print-nonprint learning materials, collaborative or dependent learning, and autonomous learning.

Factor analysis

The Riding & Sadler Smith (1992) and Sadler-Smith & Riding (1999) studies both employed factor analysis in their identification of a learner typology based on cognitive styles. Working with data from the *CLSI*, Gruber & Carriuolo (1991) have also attempted the development of a learner typology through factor analysis. In the current study, the ranking data indicates that the Wholist-Analytic dimension may be evident, and also that the Social-Independent and Conceptual-Applied factors identified by Gruber & Carriuolo (1991) may also be evident. Additionally, Sadler-Smith & Riding (1999) have also shown, through factor analysis of learning preferences data, that there are dimensions associated with collaborative, dependent, and autonomous learning.

Factor 1 has been interpreted as *Verbal–Non-verbal*. The identification of this factor is similar to that of Gruber & Carriuolo's (1991) Conceptual-Applied factor which had high positive loadings on subscales Organisation, Qualitative, Listening and Reading, and high negative loadings on the Inanimate, Iconic and Direct Experience subscales. While the Conceptual-Applied factor is similar to that shown in the present study it is suggested that, in a context of learning preferences, the Sadler-Smith and Riding (1999) preferences factor of Print and Non-print provides a more appropriate description. The Sadler-Smith & Riding (1999) identification of this factor indicates that the print versus non-print dimension of preference is an important underlying determinant of preferences among the busines students in their sample. In the current study, though, the Print–Non-print interpretation needs to be broadened to include the loadings of subscales Qualitative and Inanimate. The factor has been interpreted more broadly to one of Verbal–Non-verbal. The technology students in the current sample have shown a preference for the Nonverbal end of this dimension, especially among the males.

A gender difference is clearly identifiable, with female technology students being significantly more disposed towards verbal content and presentation than the male students, shown in the earlier Smith & Lindner (1986) research, and consistent with findings by Brainard & Ommen (1977) and Heikkinen et al. (1985). This finding may provide evidence that female students are more likely to engage with technology learning at a conceptual level than their male counterparts, who appear to be more 'hands on' in their orientation.

Factor 2 (*Collaborative–Dependent Learning*) may be interpreted to describe a dimension where, at the one end students have a preference for collaborative learning, and constructing learning in a social context while, at the other end of the dimension, their learning is in response to the structure and detail provided for them in the program design. This factor is similar to that identified as collaborative learning by Sadler-Smith & Riding (1999), where students high on collaborative learning were most interested in teaching methodologies that included role plays and discussions. The factor also appears to include the dependent instructional preferences factor identified by Sadler-Smith & Riding (1999), in that the Detail subscale also loads highly on it. Adding to the evidence that the Sadler-Smith and Riding dependent factor is included is the high loading on the factor of the Organisation subscale which, however, does not load distinctively on the factor since it also loads on Factor 3. Technology students in the current sample appear to be spread along this Collaborative-Dependent dimension, with each of the subscales loading on the factor being expressed as high or relatively

high preferences. The identification of a Collaborative-Dependent learning factor as well as a Self-directed learning factor (Factor 3) is consistent with the Sadler-Smith & Riding (1999) identification of two separate factors. The identification of two separate factors is, however, different from the Gruber & Carriuolo (1991) finding of a single Social–Independent factor.

In a technology program, collaborative learning also includes the demonstration of technique by a fellow worker or instructor, and the mentoring relationship advocated as part of the provision of scaffolding as discussed by Farmer et al. (1992), Dreyfus (1982) and Billett (1994). A preference for dependent learning, on the other hand, is characterised by Sadler-Smith & Riding (1999) as a liking for instructor-led lectures, classes and tutorials.

The absence of a gender difference in this factor provides little support for the Heikkinen et al. (1985) finding that females have a higher preference than do males for a learning context that provides clear instruction and detail. There was a difference, however, between the age-groups for this factor, with the younger students identified as significantly more collaborative than the older students, consistent with the finding by Ommen et al. (1979) that younger students are more affiliative.

Factor 3 has been interpreted as *Self-directed learning*, with the subscales of Independence and Goal Setting loading positively on it, and the Authority subscale loading negatively on it. The current sample of technology students have ranked Goal Setting relatively high in their preferences, and the other two subscales are ranked relatively low. The ranking and means data would indicate that while students are not well disposed towards independent learning, they do have liking for developing their own learning goals, and little taste for instructors who exercise authority and control in the learning setting. Again, this factor provides partial evidence for the Sadler-Smith & Riding (1999) identification of a factor associated with autonomous learning, where students who score highly on their autonomous factor have a preference for independent learning, resource based learning and computer assisted learning. The association of goal-setting with independence was also shown in the Social-Independent factor identified by Gruber & Carriuolo (1991). It is useful here, though, to remember the distinction made by both Wright (1987) and Morgan (1993) between independent learning conceptualised as learning by oneself, and independent learning in its self-directed sense where learners take responsibility for their own learning by setting their own goals and monitoring progress. The Gruber & Carriuolo factor appears to be associated with that second conceptualisation of independent learning, as self-directed learning. The Sadler-Smith & Riding (1999) autonomous factor appears more likely to measure the former conceptualisation of independent learning since

the questionnaire they used to gather their instructional preferences data did not include scales associated with goal-setting, nor any equivalent.

The analysis of variance computed on the factor scores also indicates that the preference or otherwise for self-directed learning is neither gender nor age related.

Implications for design of flexible delivery

The evidence provided in the present study that technology learners are Wholists (Riding & Cheema, 1991) indicates that they are likely to be accepting of the structure of learning programs and instructional materials provided by the instructor, and will have difficulty re-structuring this material to serve different purposes (Witkin et al., 1977). Riding & Sadler-Smith (1992) have also shown that Wholists need considerable structure to be provided to them in the learning program presentation, in the instructional materials, and in the advance organisers provided. The development of expertise has been viewed by writers such as Dreyfus (1982) and Farmer et al. (1992) as involving the incremental development of skill from novice to expert, partially through the gradual withdrawal of the scaffolding provided for learning. As the skill development increases, the need for scaffolding reduces such that is gradually withdrawn. Billett (1993) has asserted that experts organise and index their knowledge so that they readily recognise patterns and solutions to unfamiliar problems. Similarly, Dreyfus (1982) has argued that a hallmark of expertise is the ability to select and strategically apply a skill appropriate to the task at hand. It can be expected that Wholists will find this gradual withdrawal of the structure provided by scaffolding difficult indicating a need in these learners for the development of analytic skills. Development of such skills will assist them to restructure learning material in different ways from those provided, as the scaffolding supports are withdrawn and as the need for the transfer of learned skills to unfamiliar situations increases. In the early stages of skill development, however, there appears to be a clear need for structure and instructor guidance.

Additionally, the provision of the preferred collaborative and dependent learning will decline as the expectation for self-directed learning and deployment of skill increases. Effective training programs need to develop a strategy for this transformation from a collaborative and dependent context towards one that is more independent and self-directed. The need for the development of self-directed learning skills, and the development of a liking for that form of learning among technology students, appear to be important if the flexible delivery of training is to be effective. Technology students appear to be in some need for the development of these skills to provide

them with confidence in self-directed learning (White, 1997). The provision of the metacognitive skills of planning for learning, developing strategies for self-directed learning, and the evaluation of their own learning and learning strategies also appear to be important components of learner preparation. The need for the development of these skills has been argued forcefully by Boote (1998), and the current investigation provides evidence for her position that the development of these metacognitive skills is neglected in the preparation of learners for flexible delivery.

Finally, it is inescapable that an amount of learning materials and resources that technology learners will need to engage with will be textually presented. Such things as equipment and procedures manuals, trade and technical magazines, workplace policies and reports and some training materials will be textually presented. The low preference assigned by these students to learning from text, and engaging with qualitative information needs to be addressed through perhaps the provision of reading and text search strategies to enable the efficient engagement with textually presented materials, or content that is qualitative in nature. The current research indicates that both males and females technology learners are in need of the development of strategies for the efficient processing of textually presented materials, but the need for strategies to assist in the engagement with qualitative information is greater among males. Finally, the research also indicates that younger students may be in need of greater assistance in developing learning strategies needed for effective flexible learning where peer and instructor support are limited.

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