Investigating Student Outcomes in an Outcomes-Based, Technology-Rich Learning Environment

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INTRODUCTION

In numerous countries around the world, there currently is a major shift in school education from what teachers do to an 'outcomes-focus' on what students achieve and an emphasis on catering for student individual differences in backgrounds, interests and learning styles. Although an effective outcomes-focused system can be extremely difficult to achieve for practical reasons, integration of information communications technology (ICT) into the learning environment has considerable potential for providing teachers with the means to manage efficiently the diverse educational provisions needed to optimise each individual student’s outcomes. In many schools, ICT is becoming more commonplace and, in some cases, the integration of ICT into the learning environment is becoming a major thrust. In the field of learning environments, therefore, there is a need for an instrument that can be used to monitor the development and effectiveness of the learning environments that teachers create which provide an outcomes-focus and which integrate the use of ICT into their teaching and learning.

This paper reports the reliability and validity of a generally applicable instrument, designed to monitor the evolution of technology-rich, outcomes-focused learning environments, as well as its use in exploring how the learning environment created by teachers influences students’ achievement, attitudes and self-efficacy.

AIMS OF THE STUDY

1. To validate widely applicable questionnaires for monitoring outcomes-focused and ICT-rich classroom learning environments and student attitudes.
2. To investigate whether outcomes-focused and ICT-rich learning environments promote student achievement, attitudes towards the subject, attitudes to use of ICT and academic efficacy.

BACKGROUND TO THE STUDY

The study draws on and contributes to the field of learning environments (Fraser, 1994, 1998a). Contemporary research on school environments partly owes inspiration to Lewin’s (1936) seminal work in non-educational settings, which recognised that both the environment and its interaction with characteristics of the individual are potent determinants of human behaviour. Since then, the notion of person-environment fit has been elucidated in education by Stern (1970), whereas Walberg (1981) has proposed a model of educational productivity in which the educational environment is one of nine determinants of student outcomes. Research specifically on classroom learning environments took off about 30 years ago with the work of Walberg (1979) and Mocs (1974) which spawned many, diverse research programs around the world (Fraser, 1994, 1998a) and the creation of Learning Environments Research: An International Journal (Fraser, 1998c). Although earlier work
often used questionnaires to assess learning environments, the productive combination of qualitative and quantitative methods is a hallmark of the field today (Tohin & Fraser, 1998).

The dimensions measured by individual classroom environment instruments can be classified according to Moos' (1974) scheme for classifying human environments. Moos identified three basic dimensions including: the Relationship Dimension, which measures the nature and intensity of personal relationships; the Personal Development Dimension, which measures the directions in which personal growth and self-enhancement occur; and the System Maintenance and System Change Dimension, which measures the extent to which the environment maintains clear objectives and control and responds to change.

Past research on learning environments provides numerous research traditions, conceptual models and research methods that are relevant to the study presented in this paper. This study draws on the rich resource of diverse, valid, economical and widely-applicable assessment instruments that are available in the field of learning environments (Fraser, 1998b) as a starting point for developing a new questionnaire ideally suited to outcomes-focused, technology-rich learning environments.

RESEARCH METHODS

Sample

The sample for the quantitative data collection (learning environment and student attitudes, including academic efficacy) included Grade 11 and 12 students from across all learning areas at an innovative new school. The total sample available for the analyses reported in this paper consisted of 1035 student responses from 80 classes.

Sevenoaks Senior College, the school in which our study was undertaken, is located in a lower socioeconomic suburb of Perth, Western Australia. The unique ICT infrastructure built into Sevenoaks is aimed at facilitating a truly outcomes-focused curriculum that allows the integration of ICT into the delivery of programs, and it provides online curriculum and electronic information management systems to teachers and students. Therefore, Sevenoaks is an ideal setting for this study of the educational benefits of outcomes-focused, technology-rich learning environments.

Instrument Development and Validation

This paper reports the reliability and validity of a widely-applicable questionnaire for assessing students' perceptions of their actual and preferred classroom learning environments in technology-rich outcomes-focused learning settings (known as the Technology-Rich Outcomes-Focused Learning Environment Inventory, TROFLEI). The validation of the questionnaire involved conducting various statistical analyses with data from a sample of 1035 student responses (e.g., factor analysis and item analysis) to refine the scales and furnish validity and reliability information (see Fraser, 1998b).

The What is Happening in this Class? (WHIC) questionnaire was drawn on especially during the development of the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI). The WHIC was originally developed by Fraser, McRobbie and Fisher (1996) and attempted to incorporate those scales that previous studies had shown to be predictors of student outcomes. A personal form was developed in conjunction with the class form. The personal form uses the same scales and comparable items as the class form, but is worded to elicit the student's perceptions of his/her individual role within the classroom, as opposed to the student's perceptions of the class as a whole (Fraser, 1998a, 1998b; Fraser, McRobbie & Fisher, 1996).

The robust nature of the What is Happening in this Class? (WHIC) questionnaire, in terms of reliability and validity, has been widely reported in studies that have used the instrument in different subject areas, at different age levels and in eight different countries (Altrude & Fraser, 2000; Dorman, 2002; Fraser & Clough, 2000; Khine & Fisher, 2001; Maggioni, Fraser, & Altrude, 2001; Moss & Fraser, 2001; Rafla & Fraser, 2002; Rast & Fraser, 1996; Zander & Fraser, 1998). All seven of the original WHIC scales were included in the new instrument, namely, Student Cohesion, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity. Three new scales were also developed for the purpose of this study, namely, Differentiation, Computer Usage and Young Adult Ethos scales.

To investigate students' attitudes, a second instrument was developed. The instrument consists of 18 items in three scales, namely, Attitude to Subject, Attitude to Computer Usage and Student Academic Efficacy. The first scale, Attitude to Subject, is based on a scale from the Test of Science-Related Attitudes (TOSRA; Fraser, 1981). The second scale is adapted from the Computer Attitude Scale (CAS) developed by Newhouse (2001). The third scale, Academic Efficacy, is based on a scale developed by Jinks and Morgan (1999).

FINDINGS AND RESULTS

Reliability and Validity of the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)

The initial version of the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) contained 80 items altogether with 8 items belonging to each of 10 scales. Extensive field-testing and instrument validation procedures led to a refined version of the TROFLEI with 76 items in 10 scales.

Data collected from the 1035 students in 80 classes were analysed in various ways to investigate the reliability and validity of both the actual and preferred versions of the TROFLEI. Principal components factor analysis followed by varimax rotation confirmed a refined structure of the actual and preferred forms of the instrument comprising 76 items in 10 scales. Nearly all items have a loading of at least 0.40 on their a priori scale and no other scale (see Table 1), with the exceptions being Item 6 from the Student Cohesion scale and Item 61 from the Differentiation scale that did not load 0.40 or above on their own or any other scale. Item 43 of the preferred version of the Cooperation scale loaded at least 0.40 in its own scale as well as the Task Orientation scale. The percentage of the total variance extracted with each factor is also recorded at the bottom of Table 1. For the actual version, the percentage of variance varies from 4.17% to 7.32% for different scales, with the total variance accounted for being 55.60%. For the preferred version, the percentage of variance ranges from 4.21% to 7.93% for different scales, with a total variance accounted for being 61.06%.
For the revised 76-item version of the TROFLEI, three further indices of scale reliability and validity were generated separately for the actual and preferred versions: the Cronbach alpha reliability coefficient (used as an index of scale internal consistency); analysis of variance results (used as evidence of the ability of each scale in the actual form to differentiate between the perceptions of students in different classrooms); and the mean correlation of a scale with other scales (used as a convenient discriminant validity index).

Table 2 reports the Cronbach alpha coefficient for the actual and preferred versions for each of the 10 TROFLEI scales for two units of analysis (individual and class mean). Using the individual as the unit of analysis, scale reliability estimates range from 0.81 to 0.94 for the actual form and from 0.85 to 0.95 for the preferred form. Generally reliability figures are even higher with the class mean as the unit of analysis (from 0.87 to 0.97 for the actual form and from 0.89 to 0.97 for the preferred form). These internal consistency indices are comparable to those in past studies that have used the WHDC (Aldridge & Fraser, 2000; Fraser & Chionh, 2000).

Using the individual as the unit of analysis, the discriminant validity results (mean correlation of a scale with other scales) for the 10 scales of the TROFLEI range from 0.18 to 0.40 for the actual form and between 0.21 and 0.49 for the preferred form. With the class mean as the unit of analysis, discriminant validity ranges from 0.37 to 0.45 for the actual form and from 0.21 to 0.49 for the preferred form. The data suggest that raw scores on the TROFLEI assess distinct but somewhat overlapping aspects of learning environment. However, the factor analysis supports the independence of factor scores on the 10 scales.

An analysis of variance (ANOVA) was used to determine the ability of the actual version of each TROFLEI scale to differentiate between the perceptions of students in different classes. The one-way ANOVA for each scale involved class membership as the independent variable and the individual student as the unit of analysis. Table 2 reports the ANOVA results showing all 10 of the TROFLEI scales differentiate significantly between classes (p < 0.01). Thus, students within the same class perceive the environment in a relatively similar manner, while the within-class mean perceptions of the students vary between classes. The eta squared statistic (an estimate of the strength of association between class membership and the dependent variable) ranges from 0.07 to 0.18 for different TROFLEI scales.

The statistics obtained for the internal consistency (alpha reliability) and the ability of each scale to differentiate between the perceptions of the students in different classrooms (eta squared statistic from ANOVA) can be considered acceptable. The data presented in Table 2, in conjunction with the factor analysis results in Table 1, support the contention that the TROFLEI is a valid and reliable classroom environment instrument for the assessment of students' perceptions of their psychosocial environments at the high school level.

Table 1:
Furniture Loadings for the Technologies-Rich Outcomes-Focused Learning Environment (TROFLEI)
Reliability and Validity of the Student Attitude and Efficacy Scales

To measure students' attitudes, the present study adapted selected scales from three instruments. The three scales are Attitude to Subject, Attitudes to Computer Use and Academic Efficacy. The original instrument consisted of 24 items, with 8 items each in each of three scales.

The data collected from 1035 student responses in 80 classes were used to perform a principal components factor analysis followed by varimax rotation. This resulted in the acceptance of a revised version of the instrument with the same three a priori factors, but with some items omitted, namely, Items 14 and 15 from the Computer Attitude scale and Item 22 from the Academic Efficacy scale. For the final version, all items loaded more than 0.40 on their own scale and less than 0.40 on the other two scales.

The scale reliability estimates range from 0.81 to 0.87 using the individual as the unit of analysis and from 0.83 to 0.92 using the class mean as the unit of analysis. The mean correlation of a scale with other scales ranged from 0.10 to 0.40 using the individual as the unit of analysis and from 0.15 to 0.23 using the class mean as the unit of analysis. The results suggest strong factorial validity, internal consistency reliability and discriminant validity for the three attitude and efficacy scales.

Table 3: Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation With Other Scales) and Ability to Differentiate Between Classrooms (ANOVA Results for Two Units of Analysis for the Modified TROFLEI)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Unit of Analysis</th>
<th>N of Items</th>
<th>Alpha Reliability</th>
<th>Mean Correlation With Other</th>
<th>ANOVA F Value</th>
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<td>0.33</td>
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<td></td>
<td>Class Mean</td>
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<td>0.84</td>
<td>0.37</td>
<td>0.44</td>
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<td>Class Mean</td>
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<td>0.44</td>
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<td>0.83</td>
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<td>0.26</td>
<td>0.40</td>
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<tr>
<td>Evaluation</td>
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<td>0.82</td>
<td>0.34</td>
<td>0.43</td>
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<td>0.44</td>
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<tr>
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<td>Class Mean</td>
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<tr>
<td>Equity</td>
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<td>0.35</td>
<td>0.44</td>
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<td></td>
<td>Class Mean</td>
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<td>0.45</td>
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<tr>
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<td>0.38</td>
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<td></td>
<td>Class Mean</td>
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<td>Computer Usage</td>
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<td>Class Mean</td>
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<td>0.93</td>
<td>0.39</td>
<td>0.42</td>
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</table>

*p<0.05 ** p<0.01
The sample consisted of 1035 students in 80 classes.
The set's criterion (which is the ratio of between- to total sum of squares) represents the proportion of variance explained by class membership.

Investigating Whether Outcomes-Focused and ICT-Rich Learning Environments Are Associated with Student Outcomes

To investigate associations between four student outcomes (student attitudes towards their subject, student attitudes towards using the computer, student self-efficacy and student achievement) and the 10 classroom environment scales, simple correlation and multiple regression analyses were conducted. A simple correlation analysis of relationships between each attitude scale and each of 10 learning environment scales was performed to provide information about the bivariate association between each learning environment scale and each student outcome. A multiple correlation analysis of relationships between each attitude scale and the set of 10 learning environment scales was conducted to provide a more complete picture of the joint influence of correlated environment dimensions on outcomes and to reduce the Type I error rate associated with the simple correlation analysis. Table 3 shows the association between each of the student outcome and each TROFLEI scale using both the individual and the class mean as the units of analysis for all analyses except for the achievement outcome (for which the sample size was not large enough to permit analyses at the class level).

Student Attitudes Towards their Subject

The results of simple correlation analysis (Table 3) indicate that all but two of the 10 TROFLEI scales, namely, Differentiation and Computer Usage, are statistically significantly and positively associated with student attitudes towards their class (p<0.01) at the individual level of analysis. Seven of the 10 scales are statistically significantly (p<0.05) related to the Attitude to Subject scale at the class mean level of analysis, namely, Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation, Equity and Young Adult Ethics. The results of the simple correlation analysis suggest that improved student attitudes towards a subject are associated with more emphasis on these scales.

The multiple correlation (R) between students' perceptions of the set of 10 TROFLEI scales and the Attitude Towards Subject scale (reported in Table 3) is 0.52 at the student level of analysis and 0.76 at the class mean level of analysis, and is statistically significant (p<0.01) for both tables. Table 3 indicates that three of the 10 TROFLEI scales uniquely account for a significant (p<0.01) amount of variance in student attitudes towards their subject (Teacher Support, Equity and Young Adult Ethics) at the student level of analysis. Teacher support is the only TROFLEI scale that is a significant independent predictor (p<0.01) of Attitude to Subject at the class level of analysis. All significant associations are positive for Attitude to Subject.

Student Attitudes to Computer Use

With the individual as unit of analysis, the results of the simple correlation analysis (reported in Table 3) indicate that nine of the 10 TROFLEI scales (with the exception being Differentiation for which the relationship is non-significant) are positively and statistically significantly (p<0.05) related to the Attitude to Computer Use scale. At the class mean level of analysis, seven of the 10 TROFLEI scales (namely, Involvement, Task Orientation, Investigation, Cooperation, Equity, Computer Usage and Young Adult Ethics) are positively and statistically significantly (p<0.01) to Attitudes to Computer Use. The multiple correlation is 0.40 and 0.62, respectively, for the individual and class...
mean levels of analysis and is statistically significant (p<0.01) for both levels. The standardized regression weights reported in Table 3 indicate that two of the 10 TROFIEL scales (Differentiation and Computer Usage) are statistically significantly (p<0.01) and independently related to the Attitudes to Computer Use at both the student and class mean levels of analysis. Also Involvement is a significant (p<0.01) independent predictor of Attitudes to Computer Use at the class mean level. All relationships are positive except those for Differentiation, and this suggests the need for further research aimed at replicating and explaining this relationship.

### Table 3

<table>
<thead>
<tr>
<th>Scale</th>
<th>Student Cohesion</th>
<th>Teacher Support</th>
<th>Involvement</th>
<th>Task Orientation</th>
<th>Investment</th>
<th>Computer Usable</th>
<th>Equity</th>
<th>Daily</th>
<th>Differentiation</th>
<th>Computer Usage</th>
<th>Using Adult Help</th>
<th>Academic Efficacy</th>
<th>Environments</th>
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</thead>
<tbody>
<tr>
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<td>0.06**</td>
<td>0.06**</td>
<td>0.06**</td>
<td>0.06**</td>
<td>0.06**</td>
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<td>0.06**</td>
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<td>0.06**</td>
<td>0.06**</td>
</tr>
<tr>
<td>Student</td>
<td>Individual</td>
<td>Class</td>
<td>Class</td>
<td>Class</td>
<td>Class</td>
<td>Class</td>
<td>Class</td>
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<td>Class</td>
<td>Class</td>
<td>Class</td>
<td>Class</td>
<td>Class</td>
</tr>
</tbody>
</table>

*p<0.05 **p<0.01

Academic Efficacy

With the individual student as unit of analysis, the results of the simple correlation analysis reported in Table 3 indicate that all 10 scales of the TROFIEL are positively and significantly (p<0.01) related to the Academic Efficacy scale. At the class mean level of analysis, eight of the 10 TROFIEL scales are positively and statistically significantly (p<0.05) related to the Academic Efficacy scale (namely, Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Investigation, Cooperation, Differentiation and Computer Usage). The multiple correlation (R) between students’ perceptions of the learning environment and academic efficacy is statistically significant (p<0.01) with both the individual (0.45) and class mean (0.81) as the unit of analysis. For the Academic Efficacy scale, scales that uniquely account for a significant proportion of variance are Involvement, Task Orientation, Investigation and Differentiation at the student level and Investigation and Differentiation at both the student and class levels. All relationships are positive for both the simple correlation and multiple regression analyses, thus suggesting a link between higher student Academic Efficacy and emphasis on the dimensions of the classroom environment that are assessed by the TROFIEL.

### Student Achievement

The study also examined whether associations exist between student achievement and dimensions of the learning environment. The student’s score, designated at the end of the academic year, was used as a measure of achievement. Given the limited sample sizes, analyses were conducted only at the student level. The results of the simple correlation analysis reported in Table 3 indicate that six of the 10 scales of the TROFIEL are positively and significantly (p<0.05) related to the student achievement score, namely, Teacher Support, Involvement, Task Orientation, Cooperation, Equity and Young Adult Ethics. The multiple correlation (R) between students’ perceptions of the learning environment and achievement is statistically significant (p<0.01) at the individual level of analysis. According Table 3, only the Equity scale uniquely accounts for a significant proportion of variance in student achievement. All significant relationships between student achievement and learning environments are positive.

### DISCUSSION AND CONCLUSION

A major contribution of the present study is the development and validation of a widely-applicable and distinctive questionnaire for assessing students’ perceptions of their actual and preferred classroom learning environments in outcomes-focused, technology-rich classroom learning settings. This research, by examining the learning environment in an innovative new school and its impact on student attitudes towards learning and computer use, academic efficacy and student achievement, has the potential to provide information to teachers on how ICT can be used in creating outcomes-focused education and promoting improved outcomes for all students.

A new questionnaire (Technology-Rich Outcomes-Focused Learning Environment Inventory, TROFIEL) measures 10 dimensions of the actual and preferred classroom environments at the high school level, namely, Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, Equity, Differentiation, Computer Usage and Young Adult Ethics. The questionnaire includes a novel structure that incorporates the actual and preferred responses on the same form, providing an economical format that reduces the amount of administration time. The questionnaire has 76 items in 10 scales and takes around 30 minutes to administer.

The total sample available for the analyses reported in this paper consisted of 1035 student responses from 80 classes. The sample included Grade 11 and 12 students from across all learning areas at Sevenoaks Senior College.

The TROFIEL has been found to be valid and reliable at the high school level across a number of different subjects and learning areas. A series of item and factor analyses led to a refined version of the TROFIEL that displays satisfactory factorial validity for both the actual and preferred versions of the questionnaire. At both the individual and class mean levels of analysis, the internal consistency reliability and discriminant validity are satisfactory for both the actual and preferred form of the TROFIEL. Further analyses support the ability of the actual responses to differentiate between classrooms on most scales. These results support the reliability and validity of the TROFIEL and.
therefore, teachers and researchers can use it with confidence in the future.

An attitude toward technology and outcomes of technology-rich, outcomes-focused learning environments, namely, Attitude to Subject, Attitude to Computer Use and Academic Efficacy. Satisfactory factorial validity, internal consistency reliability and discriminant validity were found for the new attitude instrument for both the individual and class mean as the units of analysis.

Data collected using the TROFLEI and attitude scales were analyzed to investigate whether associations exist between the classroom learning environment and achievement and three affective outcomes (student attitude toward their subject, student attitude toward computer use and student academic efficacy). The results suggest that Teacher Support, Equity and Young Adult Ethics uniquely account for a significant amount of variance in students’ attitudes toward their subject. For associations between student attitudes to computer use, the results indicate that Differentiation and Computer Usage are significantly and independently related to the students’ attitudes to computer use at the individual level of analysis. An examination of associations between academic efficacy and the learning environment suggests that, with the individual as the unit of analysis, Involvement, Task Orientation, Investigation and Differentiation independently account for a significant proportion of variance in Academic Efficacy. Finally, the study examined whether associations exist between students’ achievement and dimensions of the learning environment. The results indicate that only the Equity scale uniquely accounts for a significant proportion of variance in student achievement.

This paper is significant because the study could have important implications for educational systems concerning how ICT can be used effectively to maximize educational outcomes for individual students. The study is innovative within the field of learning environments because of its focus on outcomes-based and technology-rich settings at an innovative new school.

ACKNOWLEDGEMENTS

The present study is funded by the Australian Research Council under its Strategic Partnerships with Industry: Research and Training Scheme (SPIRT). The contributions of a number of organizations have contributed to the study and we would like to acknowledge the assistance of the Australian Research Council, Education Department of Western Australia, AlphaWest, CISCO Systems, ACEIR Computers and RM Australasia.

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