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Working toward an international assessment of ocean literacy: Validating instrument with Rasch measurement model

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OBJECTIVES

This study is part of a larger multinational effort to construct an international assessment of ocean literacy. This work examines the psychometric properties of the English version of the most recently developed International Ocean Literacy Survey (Version 4) using the Rasch measurement framework. The goal is to establish that the set of items that have passed expert review on item design and alignment with the ocean literacy principles also meet the strict standards of psychometric analysis. Psychometric studies including, reliability and unidimensionality, item analysis, and differential item functioning (DIF) are performed to evaluate the measurement quality.

PERSPECTIVES

The ocean plays a variety of crucial roles that support the health of the earth, the livelihood of the earth's inhabitants, as well as economic, social, and environmental values/resources for humans. Human activities, however, have impacts on marine ecosystems, which, if sufficiently disrupted could pose a threat to the wellness of all living things. Given that there is only one ocean shared by all members of this planet and the importance of the ocean for earth's wellbeing, it is critical that members of the international community understand the impacts their activities have on the ocean.

Ocean literacy refers to an understanding of the ocean's influence on us and our influence on the ocean. Specifically, "*an ocean-literate person understands the fundamental concepts about the functioning of the ocean; can communicate about the ocean in a meaningful way; and is able to make informed and responsible decisions regarding the ocean and its resources* (Cava, Schoedinger, Strang, & Tuddenham, 2005, p.5)." In an effort to promote ocean literacy around the world, there is an increasing number of initiatives, movements, communities, and efforts around the topic of ocean literacy, for example, the creation of marine educator's association such as National Marine Educators Association, European Marine Science Educators Association, and Asia Marine Educator Association. Among these communities' movements, one of the key demands is to develop an ocean literacy instrument that can be used across the world, aiming to facilitate the communities' capacity to investigate the impacts of particular interventions, to examine the ocean literacy within the communities over time, and to compare ocean literacy across communities. To respond to this need, this research team collaborated with

marine science organizations and experts as well as experts in assessment to engage in the process of the international ocean literacy survey (IOLS) development. Recently, the IOLS has been field tested in early 2019 for its fourth version.

The IOLS was originally developed in English, with four rounds of content revision with inputs from the marine education community at large and revision from international advisors with expertise such as psychometrics, marine science, teaching and communications. After the Englsih version of the IOLS was finalized, the survey was then translated into 13 other languages (Catalan, Dutch, Greek, Italian, Japanese, Korean, Polish, Portuguese, Simplified Chinese, Spanish, Tagalog, Thai, and Traditional Chinese). Given the nature of the IOLS development process, it is very important to ensure a psychometrically sound measurement of the English version of the IOLS before further investigating the other language versions of the survey. In doing so, we can remove potential construct irrelevant factors such as translation bias or cultural dependency (i.e., individuals whose item responses are likely to be dependent if they shared the same culture) which may be present and play a role in affecting the measurement and estimation of students' ocean literacy. Since the development and expert vetting of the instrument was completed using the English version of the IOLS, it can serve a reference or baseline as other language versions of IOLS data are being analyzed. For example, if an IOLS item is free from differential item functioning (DIF) in the English version but it shows DIF in other language data, further investigation needs to explore the potential causes (e.g., such as translation, culture, or geographic area) that are associated with the test fairness.

METHODS

Data

Participants were high school students with ages ranging from 15 to 17 years-old. These ages were selected to be near the end of compulsory schooling to minimize international variation on when marine science is included in the national curriculum. Data were collected online during January to March 2019 through Qualtrics. There were 1,481 valid respondents (from out of 6,068 valid respondents at the international level) for the English version in the data for analysis. Among them, 47.9% were males and 49% were females.

Measures

The instrument in this study is the fourth version of the IOLS. It was most recently developed and released to the public. The IOLS originally contains 86 ocean content knowledge items. Four items have been removed from the prior stage of content review due to some defects in the item design or content. Appendix lists the English version of the IOLS items. The first 40 items are multiple choice items, each with four response options. Here is a sample multiple choice item:

O22: In the ocean, organisms are found:

(A) at the surface, in the water column, on the seafloor, and on the seashore,
(B) at the surface, on the seafloor, and on the seashore but not in the water column,
(C) on the seafloor and in the water column, but not on the surface or on the seashore,
(D) mostly in the water column and on the sea floor but not at the surface or on the seashore.

The rest of the 42 items are true-false response format. Students read a statement about ocean contents then determine whether the given statement is true or false. Here is an example:

O76: People who live far from the ocean do not cause pollution in the ocean. (TRUE) or (FALSE).

Analysis

We perform psychometric studies including reliability and unidimensionality assessment, item-level responses analysis, and differential item functioning (DIF) to evaluate the measurement quality.

For reliability, we report ordinal alpha (Gadermann, Guhn, & Zumbo, 2012; Zumbo, Gadermann, & Zeisser, 2007) which provides a more accurate reliability estimate for the ordinal scored items (e.g., binary or categorical). A value larger than 0.8 is acceptable.

For unidimensionality and construct validity, we performed confirmatory factor analysis (CFA) with weighted least squares estimator, which allows for modeling categorical or ordinal data. Outcomes statistics include Tucker-Lewis Index, Comparative Fit Index, Standardized Root Mean Square Residual, and Root Mean Square of Approximation. Both reliability and unidimensionality assessments are computed in R (R Core Team, 2019).

Item analysis and differential item functioning are estimated within the Rach measurement model (Rasch, 1960) via Winsteps (Linacre, 2019a). The Rasch model is assumed for modeling the IOLS given binary-scored item responses (1 = correct, 0 = incorrect). The Rasch model is expressed as:

$$P(x|\theta_j) = \frac{\exp(\theta_j - \beta_i)}{1 + \exp(\theta_j - \beta_i)}$$

where P is the probability of a correct response to item *i* by a respondent *j* with ability theta. Beta *i* is difficulty parameter for item *i,* and theta *j* is ability parameter for a respondent *j*. A student' performance on the IOLS is determined by ocean literacy knowledge and item difficulty.

Item fit statistics include INFIT and OUTFIT. According to Linacre (2019b), OUTFIT detects unexpected responses to items with a difficulty distant from a person's ability level. INFIT detects unexpected responses to items that are aligned to a person's ability level. Items are considered as potentially misfitting if INFIT or OUTFIT mean-square statistics were smaller than 0.5 or larger than 1.5.

Distractors analysis is performed to determine whether multiple choice item response options function effectively. Desirable distractors should attract students to choose them when students are unsure of the correct answer but should not be so attractive that students choose them more often than the correct answer. An item response option that was chosen less than 5% of the time was flagged for follow up discussion and potential revision.

DIF analysis relates to test fairness which evaluates whether items function differentially across groups. This study performs gender DIF to answer the question: does any item disadvantage a particular gender group? In this study, an item would be flagged as potential gender DIF if Rasch-Welch *t* test and Mantel-Haenszel chi-square are both statistically significant, plus with a DIF effect size larger than 0.64 logits (see Linacre, 2019b).

RESULTS

Reliability. The reliability was excellent (ordinal alpha = 0.95), meaning that all items in the ocean literacy scale had high internal consistency.

Unidimensionality. CFA model fit indicators (i.e., CFI = .903, TLI = .901, RMSEA = .041, SRMR = .046) were acceptable (see Hu & Bentler 1999) meaning that the English version of the IOLS scale was unidimensional.

Item fit. Overall, the set of IOLS items were fitting well with the Rasch measurement model (mean INFIT = 1.00, mean OUTFIT = 0.98). Among 82 items, O45's OUTFIT value (1.53) was only slightly above the range and it would not distort or degrade the measurement quality (Table 1).

Item-level analysis. Item difficulty estimates ranged from -1.652 to 2.673 (Table 1), a desirable feature that no items that are too difficult or too easy are included. The most difficult item was O26 (*beta* = 2.67) and O21 (*beta* = 2.53), both had item difficulty estimates above 2 standard deviations of the mean of the person ability estimates (Figure 1). The mean of the person ability estimates (mean = .63) were slightly higher than the mean of difficulty estimates (mean = 0), meaning that overall the set of items weren't too challenging for the respondents. Several items' difficulty estimates were below 2 standard deviations of the mean of the person ability estimates such as O66 or O58. Figure 2 lists the observed average measures of person by category score per item. All of the 82 items had clearly advancing average measures (i.e., ordered) for score categories. That is, students who answered correctly (score =1) had higher average measures of ability measures than students who answered incorrectly (score =0). Besides, the majority of the items had wide distance and between the scores of 0 and 1 in terms of observed average person ability measures, except for questions O13, O61 in which students' average ability measures between who got item correct and wrong were too close. Table 2 lists the distribution for the multiple-choice items. Among 40 multiple choice items, only three item options were not sufficiently attractive to respondents (O01_D, O07_C, O15_D, O17_D). For example, only 2.6% of the respondents chose the fourth option of the item O17, meaning that these distractors were not providing useful information to differentiate respondents with low and high ocean literacy. Besides, there were few distractors being chosen much more than the correct answers, including O21_C and O26_A. For example, the first option for the item O26 was too attractive that 53.2% of respondents chose it as the correct answer. These item options would benefit from a thoughtful revision.

Gender DIF. Table 3 lists the gender DIF analysis. Findings demonstrate that the English version of the IOLS was free from gender DIF. None of the 82 items functioned differentially between genders. In other words, none of the items in the English version of the IOLS favors/advantages or disfavors/disadvantages a specific gender group.

In summary, the English version of the IOLS is a psychometrically sound instrument with good measurement properties including internal consistency reliability, construct validity, goodness of fit structure, item level characteristics, and absence of gender DIF.

SIGNIFICANCE

This study demonstrates the psychometric soundness of the English version of IOLS. This research can serve as a model and reference for validating the international level of the ocean literacy survey, and can serve as the foundational piece as researchers and practitioners are exploring other language versions of the IOLS findings. This research will contribute to the environmental education fields with the reliable, valid, and psychometric solid measurement tool for measuring youth ocean literacy across the world.

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Table 1: Item measures and item fit statistics

Item	Difficulty	S.E.	INFIT	OUTFIT	Item	Difficulty	S.E.	INFIT	OUTFIT
O01	0.635	0.057	1	1	O42	-1.134	0.076	1.04	1.1
O02	-1.055	0.071	0.97	0.87	O43	-1.013	0.074	1.04	1.28
O03	0.246	0.058	1.02	1.02	O44	-1.625	0.089	0.93	0.74
O04	-0.182	0.060	0.97	0.93	O45	-0.317	0.064	1.17	1.53
O05	1.039	0.058	1.13	1.19	O46	-1.196	0.078	0.92	0.77
O06	1.170	0.059	1.11	1.17	O47	0.324	0.060	1.23	1.27
O07	-0.541	0.063	1.05	1.12	O48	1.152	0.061	1.17	1.27
O08	0.096	0.058	0.89	0.85	O49	-1.177	0.077	0.93	0.89
O09	-0.184	0.060	0.99	1	O50	0.090	0.062	1.04	1.04
O10	0.060	0.059	0.94	0.91	O51	-0.946	0.073	0.94	0.96
O11	-0.228	0.061	0.98	0.95	O52	-0.765	0.070	1.06	1.2
O12	0.012	0.060	0.95	0.92	O53	-0.937	0.073	0.88	0.73
O13	1.734	0.064	1.21	1.43	O54	-1.348	0.081	0.91	0.78
O14	0.494	0.057	0.98	0.96	O55	-0.700	0.069	0.94	0.85
O15	0.810	0.058	1.16	1.19	O56	-0.897	0.072	0.95	0.84
O16	1.616	0.062	0.95	0.97	O57	0.176	0.061	1.17	1.27
O17	-0.433	0.063	0.88	0.78	O58	-1.652	0.090	0.86	0.6
O18	0.038	0.059	1.04	1.05	O59	-0.392	0.065	1.07	1.13
O19	0.406	0.058	1	0.98	O60	-1.301	0.081	0.87	0.64
O20	1.807	0.065	1.15	1.22	O61	0.479	0.060	1.24	1.29
O21	2.531	0.077	1.1	1.33	O62	0.164	0.061	1.03	1.02
O22	0.597	0.058	0.89	0.88	O63	-0.277	0.064	1.01	0.96
O23	0.892	0.058	0.93	0.94	O64	-1.215	0.079	0.88	0.66
O24	0.756	0.058	0.96	0.98	O65	-0.319	0.065	1.01	0.97
O25	0.924	0.058	1.11	1.14	O66	-1.465	0.085	0.88	0.66
O26	2.673	0.080	1	1.27	O67	-0.632	0.068	0.92	0.91
O27	0.696	0.058	1.02	1.03	O68	-0.106	0.063	0.95	0.91
O28	0.682	0.058	0.98	0.98	O69	-1.367	0.083	0.84	0.61
O29	1.136	0.059	0.97	0.96	O70	-0.216	0.063	1.07	1.11
O30	0.820	0.058	1.06	1.09	O71	0.187	0.061	1.18	1.23
O31	0.680	0.058	0.81	0.78	O72	-0.993	0.074	0.95	0.95
O32	0.215	0.059	0.9	0.86	O73	-1.599	0.089	0.87	0.64
O33	0.250	0.059	0.91	0.89	O74	-0.054	0.063	1.14	1.23
O34	1.454	0.062	1.03	1.02	O75	-0.986	0.075	0.91	0.84
O35	1.053	0.059	0.96	0.98	O76	-0.744	0.071	0.97	0.85
O36	1.793	0.065	1.07	1.12	O77	-1.006	0.076	0.92	0.89
O37	0.131	0.059	0.87	0.85	O78	0.617	0.061	1.08	1.1
O38	1.037	0.059	1.12	1.17	O79	-1.170	0.079	0.89	0.72
O39	-0.072	0.060	0.83	0.78	O80	0.648	0.061	1.12	1.16
O40	0.311	0.058	0.78	0.73	O81	-0.562	0.068	1.06	1.17
O41	-0.897	0.071	0.98	0.93	O82	-0.930	0.074	0.93	0.81

Table 2. Multiple choice distribution (%)

Item	A	B	C	D
O01	24.5	**49.3**	20.7	4.3
O02	**80.2**	7.0	5.9	5.4
O03	**56.9**	22.7	7.7	10.6
O04	13.0	**65.1**	6.8	12.3
O05	23.4	**40.2**	17.7	15.8
O06	**37.4**	23.8	23.8	11.6
O07	4.5	17.8	3.4	**71.5**
O08	**59.1**	15.2	14.6	7.4
O09	11.4	**64.6**	13.8	6.8
O10	14.3	**60.0**	16.5	5.7
O11	13.9	**65.1**	8.4	8.7
O12	13.6	13.8	**58.8**	7.4
O13	**26.1**	13.1	24.1	31.1
O14	27.3	**50.7**	10.2	7.8
O15	12.0	**44.1**	34.8	4.7
O16	9.9	19.1	37.9	**28.5**
O17	15.4	**68.1**	9.3	2.6
O18	10.2	12.5	**59.6**	13.2
O19	15.1	**52.0**	20.8	7.3
O20	9.7	35.7	24.3	**25.2**
O21	10.5	20.0	49.3	**15.1**
O22	**48.0**	17.2	15.8	13.8
O23	25.2	14.5	**41.9**	13.0
O24	**44.6**	18.4	13.4	18.3
O25	33.6	14.7	**41.3**	5.3
O26	53.2	14.2	13.5	**13.5**
O27	**45.6**	25.8	14.2	8.4
O28	13.8	21.1	**46.0**	13.4
O29	18.4	30.1	8.6	**36.9**
O30	8.6	37.1	**42.9**	5.1
O31	19.0	14.9	14.1	**45.8**
O32	18.2	12.2	**55.2**	8.4
O33	**54.4**	13.9	12.3	13.3
O34	22.3	13.8	26.5	**30.7**
O35	21.7	24.6	**38.1**	8.6
O36	37.0	19.9	11.1	**24.8**
O37	11.7	13.2	**56.2**	11.8
O38	26.3	18.6	**38.6**	10.1
O39	**60.4**	14.7	12.6	5.8
O40	14.0	15.6	11.1	**53.1**

Note. Bold: answer

Table 3: DIF analysis

Item	Gender	Measure	Gender	Measure	DIF Contrast	Rasch-Welch		Mantel-Haenszel	
						t	Prob.	Chi-square	Prob.
O01	F	0.610	M	0.686	-0.076	-0.66	0.510	0.285	0.594
O02	F	-1.020	M	-1.113	0.093	0.64	0.519	0.290	0.590
O03	F	0.275	M	0.246	0.029	0.25	0.802	0.043	0.836
O04	F	-0.049	M	-0.287	0.237	1.95	0.051	5.742	0.017
O05	F	1.121	M	0.957	0.164	1.4	0.163	1.473	0.225
O06	F	1.223	M	1.132	0.092	0.77	0.441	0.018	0.892
O07	F	-0.681	M	-0.448	-0.233	-1.81	0.071	3.097	0.079
O08	F	0.069	M	0.130	-0.061	-0.51	0.607	0.000	0.995
O09	F	-0.130	M	-0.235	0.105	0.86	0.389	0.599	0.439
O10	F	0.233	M	-0.112	0.345	2.9	0.004	9.588	0.002
O11	F	-0.387	M	-0.054	-0.332	-2.7	0.007	6.931	0.009
O12	F	-0.109	M	0.132	-0.241	-1.99	0.047	3.754	0.053
O13	F	1.591	M	1.870	-0.279	-2.15	0.032	3.069	0.080
O14	F	0.494	M	0.494	0.000	0	1.000	0.447	0.504
O15	F	0.746	M	0.879	-0.133	-1.14	0.253	1.052	0.305
O16	F	1.642	M	1.616	0.026	0.21	0.837	0.138	0.710
O17	F	-0.242	M	-0.651	0.410	3.2	0.001	15.772	0.000
O18	F	-0.131	M	0.145	-0.276	-2.3	0.022	1.036	0.309
O19	F	0.501	M	0.338	0.164	1.4	0.162	0.804	0.370
O20	F	1.924	M	1.665	0.258	1.97	0.049	4.338	0.037
O21	F	2.677	M	2.416	0.260	1.66	0.097	2.516	0.113
O22	F	0.597	M	0.633	-0.036	-0.31	0.756	1.135	0.287
O23	F	0.892	M	0.892	0.000	0	1.000	0.261	0.609
O24	F	1.030	M	0.488	0.543	4.61	0.000	19.050	0.000
O25	F	0.880	M	0.986	-0.106	-0.9	0.370	0.912	0.340
O26	F	2.651	M	2.718	-0.067	-0.41	0.684	0.163	0.686
O27	F	0.761	M	0.641	0.120	1.02	0.308	0.622	0.430
O28	F	0.622	M	0.727	-0.106	-0.9	0.367	0.619	0.431
O29	F	1.065	M	1.202	-0.136	-1.13	0.257	1.696	0.193
O30	F	0.891	M	0.765	0.126	1.06	0.287	0.672	0.412
O31	F	0.719	M	0.629	0.090	0.76	0.446	1.524	0.217
O32	F	0.133	M	0.289	-0.156	-1.31	0.189	0.649	0.421
O33	F	0.250	M	0.280	-0.030	-0.25	0.802	2.005	0.157
O34	F	1.454	M	1.454	0.000	0	1.000	0.315	0.574
O35	F	1.143	M	0.984	0.159	1.32	0.187	1.816	0.178
O36	F	1.839	M	1.793	0.046	0.35	0.728	0.004	0.951
O37	F	0.111	M	0.131	-0.020	-0.17	0.867	0.009	0.924
O38	F	1.090	M	0.990	0.100	0.84	0.403	0.032	0.858
O39	F	-0.123	M	-0.018	-0.105	-0.86	0.390	0.306	0.580
O40	F	0.311	M	0.331	-0.021	-0.17	0.863	0.003	0.955
O41	F	-0.745	M	-1.045	0.300	2.06	0.039	5.281	0.022
O42	F	-1.134	M	-1.197	0.063	0.41	0.683	0.003	0.957
O43	F	-1.105	M	-0.972	-0.133	-0.88	0.377	0.248	0.618
O44	F	-1.792	M	-1.496	-0.296	-1.62	0.105	3.873	0.049
O45	F	-0.411	M	-0.279	-0.132	-1.01	0.313	0.293	0.589
O46	F	-1.224	M	-1.174	-0.050	-0.32	0.752	0.238	0.626
O47	F	0.257	M	0.394	-0.137	-1.12	0.262	2.091	0.148

Item	Gender	Measure	Gender	Measure	DIF Contrast	Rasch-Welch		Mantel-Haenszel	
						t	Prob.	Chi-square	Prob.
O48	F	1.288	M	0.977	0.311	2.51	0.012	3.477	0.062
O49	F	-1.147	M	-1.206	0.059	0.38	0.707	0.384	0.535
O50	F	0.251	M	-0.071	0.322	2.58	0.010	6.245	0.013
O51	F	-1.042	M	-0.876	-0.166	-1.12	0.264	1.457	0.227
O52	F	-0.791	M	-0.765	-0.026	-0.18	0.857	0.001	0.981
O53	F	-0.809	M	-1.093	0.284	1.91	0.056	4.686	0.030
O54	F	-1.517	M	-1.264	-0.252	-1.5	0.133	1.931	0.165
O55	F	-0.580	M	-0.821	0.242	1.72	0.086	1.756	0.185
O56	F	-0.978	M	-0.869	-0.109	-0.73	0.463	0.001	0.981
O57	F	0.277	M	0.067	0.210	1.69	0.091	3.468	0.063
O58	F	-1.652	M	-1.739	0.087	0.47	0.640	0.084	0.772
O59	F	-0.354	M	-0.392	0.038	0.29	0.774	0.351	0.554
O60	F	-1.366	M	-1.257	-0.109	-0.66	0.510	0.060	0.806
O61	F	0.540	M	0.446	0.094	0.77	0.441	0.375	0.540
O62	F	0.209	M	0.164	0.045	0.36	0.716	0.114	0.735
O63	F	-0.277	M	-0.277	0.000	0	1.000	0.163	0.686
O64	F	-1.141	M	-1.292	0.151	0.94	0.347	1.149	0.284
O65	F	-0.200	M	-0.396	0.196	1.5	0.134	1.689	0.194
O66	F	-1.465	M	-1.508	0.044	0.25	0.800	0.059	0.808
O67	F	-0.721	M	-0.574	-0.147	-1.06	0.290	0.820	0.365
O68	F	-0.276	M	0.049	-0.324	-2.54	0.011	8.524	0.004
O69	F	-1.421	M	-1.338	-0.083	-0.49	0.623	0.007	0.933
O70	F	-0.267	M	-0.165	-0.102	-0.79	0.428	0.475	0.491
O71	F	0.358	M	0.016	0.343	2.77	0.006	3.521	0.061
O72	F	-0.866	M	-1.124	0.258	1.71	0.088	3.697	0.055
O73	F	-1.806	M	-1.408	-0.398	-2.18	0.029	5.430	0.020
O74	F	-0.188	M	0.051	-0.239	-1.86	0.063	3.618	0.057
O75	F	-1.127	M	-0.861	-0.266	-1.74	0.083	4.418	0.036
O76	F	-0.948	M	-0.557	-0.391	-2.71	0.007	6.461	0.011
O77	F	-1.330	M	-0.733	-0.597	-3.82	0.000	18.796	0.000
O78	F	0.459	M	0.766	-0.307	-2.48	0.013	5.051	0.025
O79	F	-1.234	M	-1.107	-0.127	-0.79	0.429	0.281	0.596
O80	F	0.684	M	0.648	0.037	0.3	0.768	0.286	0.593
O81	F	-0.614	M	-0.503	-0.111	-0.8	0.422	0.005	0.946
O82	F	-1.150	M	-0.729	-0.421	-2.77	0.006	4.754	0.029

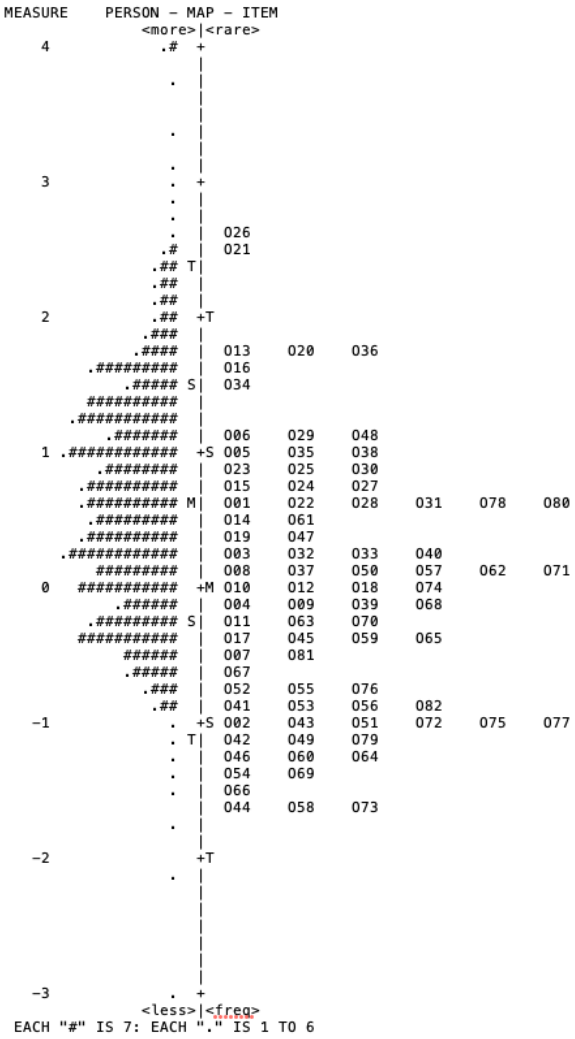

Figure 1: Item-person map

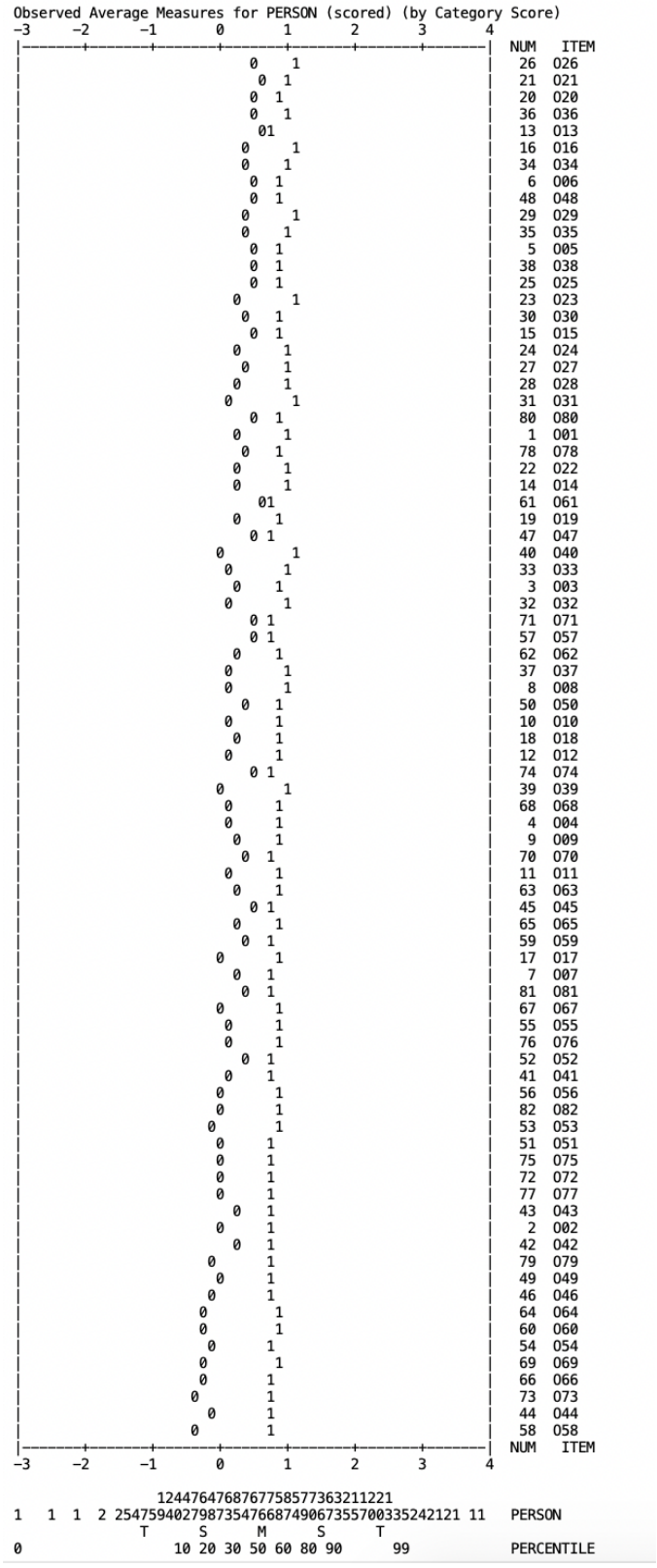

Figure 2: Observed average measures of person by category score per item

Appendix: The English version of the International Ocean Literacy Survey

Select the one best response for each question

O01 What is the best explanation of how ocean water moves?
Water in each ocean basin (e.g., Atlantic, Pacific, Indian) moves only within that basin.
**Water in the Pacific ocean basin will eventually move to all other ocean basins.
Ocean water moves throughout either the northern hemisphere or the southern hemisphere. Water does not cross the equator.
Water in smaller basins, like the Mediterranean Sea, remains there and does not move to other basins.

O02 Because the ocean covers most of the Earth:
**it has the most dominant influence on Earth's weather and climate.
most living things are concentrated on land.
most of the Earth is not useful for humans.
it generates most of the Earth's greenhouse gases.

O03 Which statement describes the main process that shapes the features of the land and the ocean floor?
**Both the land and the ocean floor are shaped by movement of the Earth's crust.
Erosion caused by rivers brings material from the land to the ocean which shapes the ocean floor.
Both land and ocean features are shaped by the wind.
Both the land and the ocean floor are shaped by changes to climate.

O04 Ocean currents are influenced by both:
global ship traffic and Earth's rotation.
**the position of land masses and Earth's rotation.
global ship traffic and the acidity of the ocean.
adjacent land masses and the acidity of the ocean.

O05 How is sea level measured?
Average depth of the ocean.
**Average height of the ocean relative to the land.
Height of the ocean relative to land at the lowest tide.
Height of the ocean relative to land at the highest tide.

O06 Which of these statements about seawater and freshwater is true?
**Seawater freezes at a lower temperature than freshwater, and seawater conducts electricity better than freshwater.
Seawater freezes at a higher temperature than freshwater, and seawater conducts electricity better than freshwater.
Seawater freezes at a lower temperature than freshwater, and freshwater conducts electricity better than seawater.
Seawater cannot freeze and seawater conducts electricity better than freshwater.

O07 Where is most of the water on Earth?
In the atmosphere.
In polar ice caps.
In rivers and lakes.
**In the ocean.

O08 Which of the following is the most accurate about the water in the Earth’s water cycle?
**Much of the same water has been traveling through the water cycle for millions of years.
Water joins the water cycle when new water is made through condensation.
Water leaves the water cycle when it evaporates from the ocean.
Water leaves the water cycle when humans and other organisms drink it.

O09 What connects the ocean to all water on Earth?
Transpiration and precipitation.
**Precipitation and evaporation.
Deposition and evaporation.
Deposition and transpiration.

O10 Rivers supply most of the salt to the ocean. The salt in the rivers comes from:
mountain ice melting.
**erosion of land.
rainfall in the rivers.
human caused pollution.

O11 Sand on the shoreline is:
likely to stay on the same beach for hundreds of years.
**continually transported by waves and currents.
continually transported by activities of animals that live there.
likely to be transported inland by wind and rivers.

O12 What occurs during an El Nino year?
There are large but temporary changes in the salinity of the ocean.
The temperature of the ocean gets colder.
**There are large but temporary changes in global weather patterns.
There are large permanent changes in global weather patterns.

O13 Most rain that falls on land originally evaporated from:
**the ocean near the equator.
the middle of each ocean basin.
nearby lakes and rivers.
the nearest ocean basin.

O14
The ocean affects climate change by absorbing, storing, and moving:
carbon and salt.
**carbon and heat.
phytoplankton and heat.
phytoplankton and salt.

O15 How is climate change impacting the Arctic?
The impact on the Arctic is the same as on the rest of the planet.
**The Arctic is warming faster than the rest of the planet.
Glaciers are melting in some parts of the Arctic and growing in other parts.
Tropical ocean fishes are migrating to the Arctic.

O16 Where did most of the oxygen in the atmosphere originally come from?
Released into the atmosphere by volcanos erupting.
From interstellar gases when the Earth was first formed.
Released during photosynthesis by land plants.
**Released during photosynthesis by marine organisms.

O17 Fossil evidence shows that life most likely first evolved:
on land.
**in the ocean.
under Earth's surface.
in outer space.

O18 What is the largest animal ever to live on Earth?
Giant squid.

Woolly mammoth.
**Blue whale.
Giganotosaurus

O19 Most living material (biomass) in the ocean is found in:
fishes (sharks, salmon, cod, etc.).
**plankton (jellyfish, krill, diatoms, etc.).
marine mammals (whales, dolphins, walruses, etc.).
molluscs (snails, clams, squid, etc.).

O20 There are over 30 major groups of organisms (vertebrates, arthropods, molluscs, etc.) on Earth. Where are most of these major groups found?
Most are found exclusively in the tropical rainforests.
Most are found on both land and in the ocean.
About half are found exclusively in the ocean.
**Almost all are found exclusively in the ocean.

O21 Both land and ocean provide space for organisms to live. How much of Earth's living space is found in the ocean?
Only a little bit (less than 10%).
About half (40–60%).
More than half (60–80%).
**Nearly all (more than 90%).

O22 In the ocean, organisms are found:
** at the surface, in the water column, on the sea floor, and on the seashore.
at the surface, on the sea floor, and on the seashore but not in the water column.
on the sea floor and in the water column, but not on the surface or on the seashore.
mostly in the water column and on the sea floor but not at the surface or on the seashore.

O23 Which of the following most influences the depth at which organisms live in the open ocean (away from the shoreline)?
Salinity levels.
Crashing waves.
**Light levels.
Human activity.

O24 What is the source of energy for ocean ecosystems where there is no sunlight?
**Chemical energy from hydrothermal vents.
Wave energy from the wind.
Nuclear energy from underwater radioactive material.
Thermal energy from volcanoes.

O25 Which of the following has the largest influence on the vertical distribution of organisms on the seashore?
Sunlight.
Salinity.
**Tides.
Trampling by people.

O26 Which of the following marine ecosystems is the most important nursery areas for many marine species?
Coral reefs (reefs formed by living corals).
The deep sea (more than 100m below the ocean surface).
The open ocean (away from the shoreline).
**Estuaries (where rivers meet the ocean).

O27 What is the best explanation of ocean acidification?

**Burning fossil fuels (coal, oil, etc.) adds carbon dioxide to the atmosphere, which is absorbed by the ocean and increases its acidity.
Pollution adds toxic chemicals to the ocean that increases its acidity.
Fertilizers from agriculture are washed into the ocean and this increases the acidity of the ocean.
Upwelling of naturally acidic sea water from deep in the ocean increases the acidity at the surface.

O28 Which of the following are happening because of human-caused changes to ocean temperatures and pH levels?
Ocean salinity is increasing and the frequency of oil spills is increasing.
The frequency of oil spills is increasing and many coral reefs are degraded or dying.
**Many coral reefs are degraded or dying and the diversity of life in the ocean is decreasing.
The diversity of life in the ocean is decreasing and ocean salinity is increasing.

O29 The use of satellites, buoys, and remotely-operated vehicles improve our understanding of the ocean because the new technologies:
reduce errors from human measurements of the ocean.
cause less disturbance to the marine environment.
are cheaper than previous tools.
**collect much more data than scientists on ships can.

O30 Sea level changes have:
reversed the direction that some rivers flow.
changed global temperatures.
** changed the shape of the coastline.
increased fish populations.

O31 Scientists are discovering that more species than they expected live in the deep sea. These discoveries are only being made now because:
environmental conditions are causing species to migrate to the deep sea.
deep sea species evolve more rapidly than shallow water species.
shallow water species have been overfished.
** scientists are just beginning to explore the deep sea.

O32 Making new discoveries about the complexity of the ocean requires:
a degree in marine biology.
living near the ocean.
**collaboration among people with different expertise.
use of SCUBA gear for diving.

O33 Over the last 50 years humans have:
**increased their use of ocean resources.
explored most of the ocean.
reduced total emissions from ships into the ocean.
reduced unsustainable use of ocean resources.

O34 Absorption of carbon dioxide (CO_2) by the ocean has a direct influence on which of the following?
The greenhouse effect and dead zones in the ocean.
Acid rain and harmful algal blooms.
Acid rain and ocean acidification.
**The greenhouse effect and ocean acidification.

O35 Clams, oysters, and other marine organisms use the carbon dissolved in the ocean to:
breathe underwater.
regulate body temperature.
**build shells.

assist in reproduction.

O36 Which of the following is true about ecological relationships in the ocean?
They are very similar to those on land, including similar food web, life cycle, and symbiotic relationships.
They are mostly unknown since so much of the ocean has not been explored.
They are mostly very simple compared to those on land.
**There are unique features of food webs, life cycles, and symbiotic relationships in the ocean that are not found on land.

O37 Which of the following is true concerning the exploration of the ocean?
People have been exploring the ocean for thousands of years and most of it has been explored.
Almost all of the ocean has been explored in the last 50 years because of new technology.
**Most of the ocean is still unexplored despite improvements in technology in the last 50 years.
Most of the ocean is still unexplored because scientists focus on the areas where most organisms live.

O38 Look at the image. If both cities are at the same elevation, it is likely that:
city A will have warmer summers and cooler winters than city B.
city A will have warmer summers and warmer winters than city B.
**city A will have cooler summers and warmer winters than city B.
city A will have similar temperatures as City B in each season.

O39 If there was no ocean, the Earth's surface temperatures would be:
**more extreme around the world.
less extreme around the world.
cooler in the summer and warmer in the winter.
about the same as they are now.

O40 Ocean resources:
are sufficient to support today's fishing practices into the future.
can always be replaced with resources from another part of the ocean.
replenish themselves quickly.
** are limited and in rapid decline around the world.

Complete each of the following sentences with the statements below them, and mark each one true or false.
Rivers can transport _____ to the ocean.
O41 nutrients (False/**True)
O42 sand (False/**True)
O43 rocks (False/**True)
O44 pollutants (False/**True)

Changes to sea level are caused by _____.
O45 movement of the continental plates (FALSE/**TRUE)
O46 melting and growing of ice caps on land (FALSE/**TRUE)
O47 warming and cooling of ocean water (FALSE/**TRUE)
O48 movement of sediments from coastal erosion (**FALSE/TRUE)

Changes to the shape of coastlines are caused by _____.
O49 sea level changes (FALSE/**TRUE)
O50 seawater salinity changes (**FALSE/TRUE)
O51 movement of the continental plates (FALSE/**TRUE)
O52 forces of waves (FALSE/**TRUE)

Humans depend on the ocean for _____.
O53 food and medicine (FALSE/**TRUE)
O54 minerals and energy resources (FALSE/**TRUE)
O55 transportation and jobs (FALSE/**TRUE)

O56 benefits to the economy (FALSE/**TRUE)
O57 nuclear fusion (**FALSE/TRUE)

Industrial development by humans has lead to _____.
O58 ocean pollution (FALSE/**TRUE)
O59 changing the shape of the coastline (FALSE/**TRUE)
O60 increasing ocean acidity (FALSE/**TRUE)
O61 Increasing the frequency of tsunamis. (**FALSE/TRUE)
O62 improving conditions for indigenous people (**FALSE/TRUE)

Humans use the ocean for _____.
O63 recreation (FALSE/**TRUE)
O64 food and medicine (FALSE/**TRUE)
O65 art and cultural heritage (FALSE/**TRUE)
O66 transportation (FALSE/**TRUE)

Caring for and protecting the ocean is the responsibility of _____.
O67 leaders of each country because they set national policies (FALSE/**TRUE)
O68 highly intelligent ocean animals like whales and dolphins (**FALSE/TRUE)
O69 individuals because everyone benefits from the ocean regardless of where they live (FALSE/**TRUE)

The ocean affects your life because it _____.
O70 provides much of the oxygen you breathe (FALSE/**TRUE)
O71 provides nuclear energy to heat your home (**FALSE/TRUE)
O72 supplies the rain that grows your food (FALSE/**TRUE)
O73 influences the climate of the place where you live (FALSE/**TRUE)

Mark each statement TRUE or FALSE.
Mark each geology statement below TRUE or FALSE
O74 Many rocks on land were formed in the ocean. (FALSE/**TRUE)
O75 Geological processes (e.g., volcanoes and earthquakes) can push rocks formed in the ocean above the surface of the ocean. (FALSE/**TRUE)

Mark each statement below about human impacts to the ocean TRUE or FALSE
O76 People who live far from the ocean do not cause pollution in the ocean. (**FALSE/TRUE)
O77 All people, regardless of where they live, cause pollution in the ocean. (FALSE/**TRUE)
O78 People who live near the ocean contribute more to ocean acidification that people who live far from the ocean. (**FALSE/TRUE)

Mark each of the statements below about the ocean and atmosphere TRUE or FALSE.
O79 Interactions between the ocean and the atmosphere strongly influence weather and climate. (FALSE/**TRUE)
O80 There are different seasons throughout the year because the ocean absorbs much of the heat from the sun. (**FALSE/TRUE)
O81 The water cycle is powered by the transfer of heat between the ocean and the atmosphere. (FALSE/**TRUE)
O82 Transfer of heat between the ocean and the atmosphere drives global circulation of water and air and can cause storms around the world. (FALSE/**TRUE)