Resources and Features of Robotics Learning Environments (RLEs) in Spain and Latin America

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APPENDIX A. CONSTRUCT VALIDITY OF A SCALE OF FEATURES FOR A ROBOTICS LEARNING ENVIRONMENT (RLE)

The mathematical procedure used to confirm the **construct validity** is *factor analysis*. From this analysis we can confirm if the internal structure of the scale adjusts to the theoretical structure according to which it has been made.

In order to check construct validity, a factor analysis was carried out to the overall sample. After carrying it out, Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was .863 and Bartlett's test of sphericity χ^2 = 414.747; df = 45; p= .000, the Principal Component Analysis (PCA) with unrotated factor was applied to the 10-item scale.

Even though results generate 2 factors, factor 1 is found to have a high relation to all the variables directly; that does not occur for the second factor and, therefore, this could be interpreted as a general "Robotics Learning Environment (RLE)" factor.
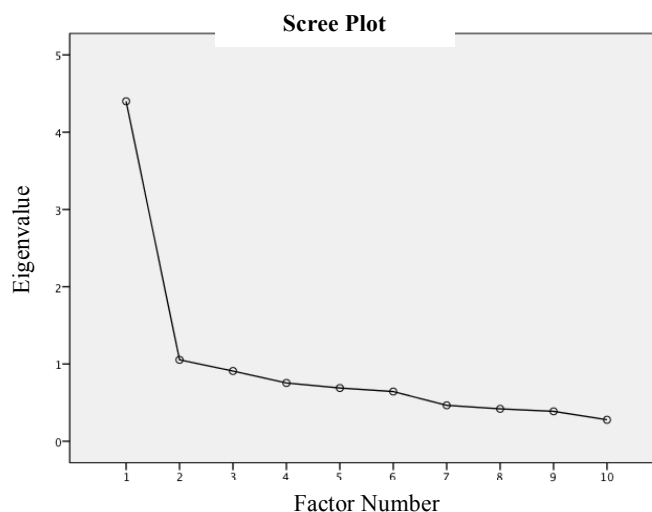
Scree Plot

Moreover, in the scree plot, the first factor is found to be separate from the rest. This fact confirms that only one factor effectively exists in the structure of this scale, which explains the higher variance showed.

Another methodological and statistical procedure which supported and deepened the interpretations which can be deducted from the first result of the factor analysis, consisted of other base factor analysis, not to the overall sample, but referred to the two learning environments: ordinary school and after school environments, which are present in the original sample.

From these factor analyses carried out by principal components, we can deduct that there is a clear trend at 0.50 from 9 items to factor 1, which provides assurance with regard to the right subject of the scale measure, that is to say, the theoretical construct "Features of an RLE" (Construct Validity).

FEATURE	Overall Sample N = 123		Ordinary School Environment N = 60		After-School Environment N = 63	
	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2
Active	**.698**	-.516	**.703**	.508	**.687**	-.455
Manipulative	**.602**	-.218	**.617**	.660	**.595**	.152
Constructive	**.797**	-.243	**.838**	.118	**.744**	-.333
Collaborative	**.625**	-.255	**.643**	-.193	**.667**	-.440
Intentional	.485	.599	**.521**	-.149	.434	.680
Complex	**.590**	.379	**.633**	-.330	**.544**	.116
Conversational	**.677**	.110	**.784**	-.349	**.501**	.078
Contextual	**.730**	.232	**.810**	-.070	**.635**	.574
Reflexive	**.748**	-.062	**.770**	-.232	**.718**	-.028
Technological	**.625**	.211	**.631**	.090	**.613**	.036
% Total variance explained	44.006	10.541	49.264	10.648	38.512	13.470
KMO	.863		.847		.804	
Determinant	.030		.007		.048	
Bartlett's Test of Sphericity — Approx. Chi-Square	414.747		271.975		176.132	
Bartlett's Test of Sphericity — df	45		45		45	
Bartlett's Test of Sphericity — Sig.	.000		.000		.000	

Statistical elements to obtain construct validity of a "Features of a RLE" scale

APPENDIX B. **SURVEYED SAMPLE ACCORDING TO COUNTRY OF ORIGIN**

COUNTRY	RLE		
	Total	Ordinary School	After-School
	127	60	67
Argentina	**6**	3	3
Bolivia	**1**	1	0
Brazil	**1**	0	1
Chile	**5**	1	4
Colombia	**3**	0	3
Costa Rica	**9**	7	2
Ecuador	**4**	0	4
El Salvador	**5**	3	2
Spain	**51**	23	28
Guatemala	**1**	1	0
Mexico	**12**	5	7
Panama	**9**	5	4
Peru	**6**	2	4
Puerto Rico	**1**	1	0
Dominican Republic	**1**	0	1
Uruguay	**5**	4	1
Venezuela	**7**	4	3

APPENDIX C. **FREQUENCY DISTRIBUTION AND PERCENTAGES FOR "PROFILE OF THE TEACHER" DIMENSION**

		RLE	
	Total	**Ordinary School**	**After School**
	127	**60 (47.2%)**	**67 (52.8%)**
ORIGIN			
Latin America	**76**	**37** (48.7%)	**39** (51.3%)
Spain	**51**	**23** (45.1%)	**28** (54.9%)
GENDER			
Female	**43**	**22** (51.2%)	**21** (48.8%)
Male	**84**	**38** (45.2%)	**46** (54.8%)
AGE (years old)			
Below 33	**28**	**7** (25.0%)	**21** (75.0%)
From 33 to 40	**43**	**24** (55.8%)	**19** (44.2%)
From 41 to 48	**37**	**17** (45.9%)	**20** (54.1%)
Above 48	**19**	**12** (63.2%)	**7** (36.8%)
FIELD OF STUDY			
Art, Humanities and Arts	**17**	**8** (47.1%)	**9** (52.9%)
Science	**28**	**17** (60.7%)	**11** (39.3%)
Engineering	**72**	**32** (44.4%)	**40** (55.6%)
Social and Legal Science	**8**	**3** (37.5%)	**5** (62.5%)
Biomedical Science	**2**	**0** (0.00%)	**2** (100%)
EXPERIENCE IN ER (years)			
Less than 4	**67**	**26** (38.8%)	**41** (61.2%)
From 4 to 9	**34**	**18** (52.9%)	**16** (47.1%)
More than 9	**26**	**16** (61.5%)	**10** (38.5%)
TRAINING IN ER*			
Experience	**90**	**43** (47.8%)	**47** (52.2%)
Self-learning	**101**	**44** (43.6%)	**57** (56.4%)
Exchange with colleagues	**68**	**37** (54.4%)	**31** (45.6%)
Non-institutional course	**39**	**16** (41.0%)	**23** (59.0%)
Voluntary institutional Course	**57**	**35** (61.4%)	**22** (38.6%)
Compulsory institutional course	**14**	**10** (71.4%)	**4** (28.6%)
Online course	**18**	**14** (77.8%)	**4** (22.2%)
Other	**2**	**1** (50.0%)	**1** (50.0%)

* Teachers were allowed to select all applicable answers.

APPENDIX D. **FREQUENCY DISTRIBUTION AND PERCENTAGES FOR "TECHNOLOGICAL RESOURCES" DIMENSION**

	RLE		
	Total	**% School**	**% After School**
	127	**47.2**	**52.8**
EDUCATIONAL ROBOTS BY CATEGORY			
EIM (**E**lectronics/**E**lectricity – **I**nformatics – **M**echanics)	**31**	**48.4**	**51.6**
Arduino Board	14	35.7	64.3
Butiá	5	80.0	20.0
Own design	5	20.0	80.0
Recyclables	4	75.0	25.0
BoE-Bot (Parallax)	1	0	100
Ícaro	1	100	0
GoGo Board	1	100	0
IM (**I**nformatics – **M**echanics)	**94**	**46.8**	**53.2**
Lego Mindstorms	84	45.2	54.8
Lego WeDo	3	66.7	33.3
FischerTechnik	3	100	0
Robo-Ed-Es	2	0	100
Multiplo	1	100	0
Ollo	1	0	100
I (**I**nformatics)	**2**	**50.0**	**50.0**
Bee-Bot	2	50.0	50.0
PROGRAMMING SOFTWARE			
Textual Interface			
Arduino	14	35.7	64.3
RobotC / C	4	50.0	50.0
NXC	3	33.3	66.7
"Ex Profeso" created	3	66.7	33.3
BricxCC	1	100	0
RoboPlus	1	0	100
Graphical Interface			
NXT-G	68	42.6	57.4
Robolab	11	54.5	45.5
Scratch	6	33.3	66.7
TortuBots	5	80.0	20.0
WeDo	3	66.7	33.3
RoboPRO / LLWin (FischerTechnik)	3	100	0
Physical Etoys	1	100	0
Minibloq	1	100	0
LabView	1	0	100

		RLE	
		% School	**% After School**
LEVEL OF INITIAL DIFFICULTY OF ROBOTICS PLATFORM			
Very low	12	58.3	41.7
Low	35	45.7	54.3
Normal	74	43.2	56.8
High	5	100	0
Very high	1	0	100
LEVEL OF INITIAL DIFFICULTY OF PROGRAMMING LANGUAGE			
Very low	12	58.3	41.7
Low	25	52.0	48.0
Normal	62	43.5	56.5
High	26	46.2	53.8
Very high	2	50.0	50.0
ADDITIONAL MATERIALS*			
Book(s)	48	58.3	41.7
Internet	92	44.6	55.4
Own use	87	48.3	51.7
Resource manufacturers	61	44.3	55.7
Organizing institution of the workshop/course	47	53.2	46.8
Other origin	1	100	0

* Teachers were allowed to select all applicable answers.

		EDUCATIONAL ROBOTS CATEGORIES			
		EIM		**IM**	
	Total	**n [$\%_{row}$]**	**n Ordinary School** **n After School**	**n [$\%_{row}$]**	**n Ordinary School** **n After School**
	125	**31** [24.8]	15 16	**94** [75.2]	44 50
GENDER*					
Female	**43**	**6** [14.0]	3 3	**37** [86.0]	19 18
Male	**82**	**25** [30.5]	12 13	**57** [69.5]	25 32
PROGRAMMING SOFTWARE*					
Textual	**26**	**20** [76.9]	9 11	**6** [23.1]	2 4
Graphical	**99**	**11** [11.1]	6 5	**88** [88.9]	42 46
AGE OF STUDENTS* [N=123]					
From 5 to 12 years old	**38**	**2** [5.3]	0 2	**36** [94.7]	16 20
From 13 to 17 years old	**85**	**29** [34.1]	15 14	**56** [65.9]	28 28

* There are statistically significant differences (p <.05)

APPENDIX F. **FREQUENCY DISTRIBUTION AND PERCENTAGES FOR "LEARNING ENVIRONMENT FEATURES" DIMENSION**

	RLE		
	Total	**% School**	**% After School**
	124	48.4	51.6
PARTICIPATION IN TOURNAMENTS			
Yes	56	42.9	57.1
No	68	52.9	47.1
AGE OF STUDENTS (years old)			
From 5 to 12	39	43.6	56.4
From 13 to 17	85	50.6	49.4
AVERAGE OF STUDENTS PER CLASS *			
Between 1 and 12	47	27.7	72.3
Between 13 and 18	30	46.7	53.3
Between 19 and 24	23	69.6	30.4
Between 25 and 30	17	64.7	35.3
Above 30	7	85.7	14.3
AVERAGE OF STUDENTS PER ROBOT*			
Two	28	42.9	57.1
Three	43	32.6	67.4
Four	34	61.8	38.2
Over four	19	68.4	31.6
SETTING UP PHASES/STAGES (N =113)			
Yes	73	43.8	56.2
No	40	52.5	47.5
ASSIGNING ROLES TO THEIR STUDENTS (N =113)			
Yes	61	44.3	55.7
No	52	50.0	50.0

* There are statistically significant differences ($p < .05$) depending on the selected RLE.

APPENDIX G. **DESCRIPTIVE ANALYSIS OF THE SCALE: RLE FEATURES**
(IN DECREASING ORDER)

FEATURE	$\bar{X}$	DE	1 Never (%)	2 Rarely (%)	3 Sometimes (%)	4 Very often (%)	5 Always (%)
Technological	4.54	.617	0	0	6.5	32.5	**61.0**
Active	4.42	.653	0	0.8	6.5	42.3	**50.4**
Collaborative	4.37	.751	0	2.4	8.9	37.4	**51.2**
Manipulative	4.37	.751	0	2.4	8.9	37.4	**51.2**
Constructive	4.26	.745	0	2.4	10.6	**45.5**	41.5
Intentional	4.12	.902	0.8	2.4	22.8	31.7	**42.3**
Reflexive	4.04	.843	0.8	4.1	16.3	**48.0**	30.9
Contextual	3.98	.830	0	3.3	25.2	**41.5**	30.1
Conversational	3.82	.887	1.6	4.9	25.2	**46.3**	22.0
Complex	3.45	.916	0	15.4	**38.2**	32.5	13.8

APPENDIX H. **DIFFERENTIAL ANALYSIS ACCORDING TO FEATURES**

RLE FEATURES

		Contextual	Intentional	Active	Manipulative	Collaborative	Reflexive	Conversational	Constructive	Complex
ORIGIN	*p*	.007								
Latin America (N=73)	$\bar{X}$	4.14								
	S	.839								
Spain (N=50)	$\bar{X}$	3.76								
	S	.771								
PARTICIPATION IN ER COMPETITIONS	*p*		.009							
Yes (N= 56)	$\bar{X}$		3.89							
	S		.928							
No (N=67)	$\bar{X}$		4.31							
	S		.839							
AGE OF STUDENTS	*p*			.007	.041					
From 5 to 12 years old (N=38)	$\bar{X}$			4.63	4.53					
	S			.633	.797					
From 13 to 17 years old (N=85)	$\bar{X}$			4.33	4.31					
	S			.643	.724					
GENDER	*p*			.031	.000	.015	.003			
Female (N=41)	$\bar{X}$			4.56	4.68	4.61	4.34			
	S			.709	.722	.586	.762			
Male (N=82)	$\bar{X}$			4.35	4.22	4.26	3.89			
	S			.616	.721	.798	.846			
ASSIGNING ROLES TO THEIR STUDENTS*	*p*	.010		.018				.026	.036	
Yes (N= 27)	$\bar{X}$	4.22		4.59				4.07	4.41	
	S	.698		.572				.781	.694	
No (N=26)	$\bar{X}$	3.65		4.15				3.42	3.92	
	S	.797		.732				1.06	.891	
SETTING UP PHASES/STAGES	*p*		.002					.002	.020	.001
Yes (N= 73)	$\bar{X}$		4.30					4.01	4.37	3.66
	S		.877					.874	.717	.885
No (N=40)	$\bar{X}$		3.77					3.50	4.02	3.03
	S		.891					.877	.800	.862

*Data pertaining to School Environment. If both environments are considered together, there is only significant difference in "collaborative" feature p=.027 (the only one registered in After School Environment with p=.031).
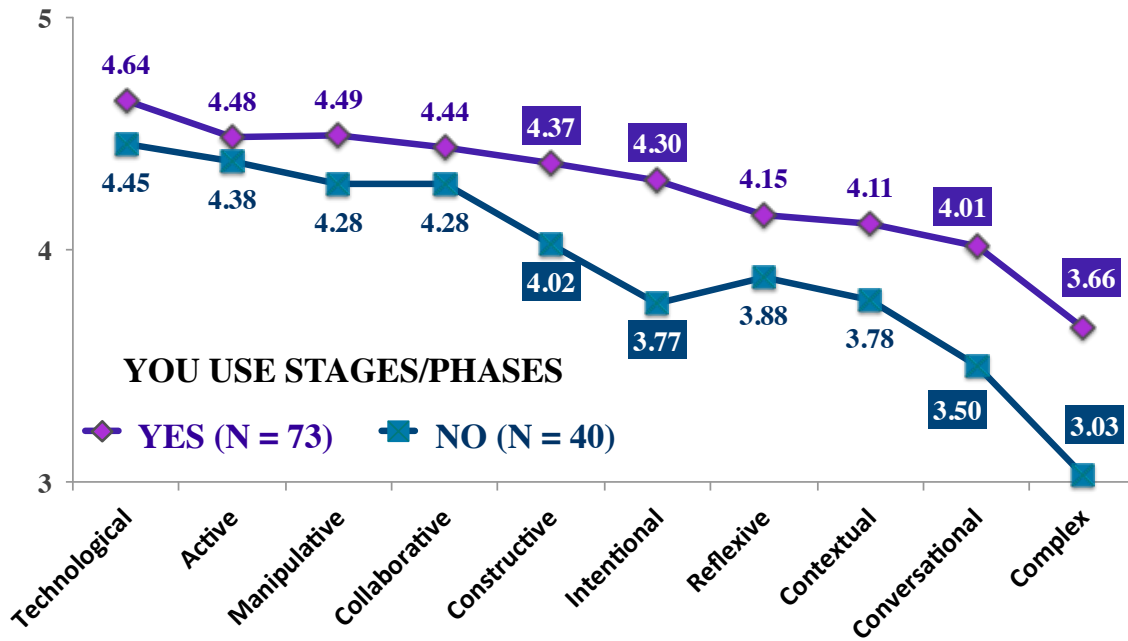
Figure 6. Average of Features depending on the Use of Stages/Phases by the Teacher

constructive (p =.020), intentional (p =.002), conversational (p=.002), and complex (p =.001)