Employing radio frequency identification technology in campus security management: the influences of parental satisfaction

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ABSTRACT: The aim of this study is to explore parental satisfaction with RFID-assisted campus security management and to promote the establishment of a safe environment for students at special schools. Purposive sampling was employed, and a SERVQUAL scale applied as the theoretical basis for the questionnaire design. Of the 102 questionnaires distributed, 89 valid questionnaires were collected; thereby, yielding a response rate of 87.25%. Data was processed using SPSS statistical software. One-way analysis of variance (ANOVA) and Pearson's product-moment correlation were conducted. The results show that highly educated parents were less satisfied with the responsiveness of the RFID compared to parents with low levels of education. Overall parental satisfaction and RFID-assisted campus security management were highly correlated. The researchers suggest applying RFID to all grade levels in special schools in order to establish a safe environment for students.

INTRODUCTION

Problem Statements

Radio frequency identification technology (RFID) in campus security management remains relatively under-researched. The purpose of this study is to explore parental satisfaction with RFID-assisted campus security management and to promote the establishment of a safe environment for students at special schools.

The US National School Safety Center stated that providing a free quality education is merely the beginning, since students also require a safe and reliable campus environment (National School Safety Center 2011) [1]. The American Association on Mental Retardation (AAMR) classified the levels of support required by people with mental retardation into four categories (AAMR, Committee on Terminology and Classification - 1992): 1) intermittent: sporadic and provided as needed; 2) limited: regular support with time restrictions, but not intermittent; 3) extensive: continual support in certain circumstances with no time restrictions; and 4) pervasive: constant, intensive and universal support, potentially required for a lifetime [2]. In the present study, 38.5% of the students required extensive and pervasive support, while 54.3% required limited support, yielding a total of 92.8% of students requiring some type of additional health-related care and protection.

Radio frequency identification technology (RFID) was first applied to campus security in Taiwan after the 2005 Executive Yuan Industrial Technology Strategy Conference [3]. The authorities strategically resolved issues to promote the national RFID industry, leading industrial development by piloting the system in public areas and applying it to campus security. The Ministry of Education divided campus security and calamity events into eight categories: 1) accidents; 2) security maintenance; 3) violent and deviant behaviour; 4) disciplinary conflicts; 5) protection of children and youths; 6) natural disasters; 7) diseases; and 8) other. Diseases, the protection of children and youths and accidents accounted for a high proportion of the eight categories. Moreover, the number of accidents substantially increased between 2009 and 2011 (The Ministry of Education, Table 1) [4].

Table 1: Frequency of campus incidents between 2009 and 2011.

Incident type	2009	2010	2011
Illness	119,718	32,390	20,712
Child and youth protection	5,804	7,603	13,889
Accidents	6,888	7,771	10,498
Violent or delinquent behaviour	2,703	3,013	7,182
Security maintenance	1,331	1,494	2,400

Disciplinary conflicts	285	377	744
Natural disasters	529	536	149
Other	912	1,097	1,782
Total	138,170	54,281	57,356

Data source: Campus Security Report Center, Ministry of Education, 2013

The campus security project implemented by the Ministry of Education in 2008 used RFID to facilitate improvements in student safety [4]. The special education schools wherein RFID was employed to improve campus security included the National Taichung Special School, the National Chiai Special School and the Affiliated Hearing Impaired School of the National University of Tainan.

LITERATURE REVIEW

Parasuraman et al defined *quality of service* as the difference between customers' experiences and expectations; that is, the gap between their post-service feelings towards the service and their pre-service expectations [5]. Hence, the performance and expectation gap model in which quality of service equals performance minus expectation (Q = P - E) was proposed. According to the Parental Satisfaction Survey of RFID-Assisted Campus Security Management, a high total score indicates a high level of parental satisfaction and *vice versa*. In general, an RFID system is primarily comprised of tags, readers and system software. Furthermore, it automatically identifies objects and transmits the data through radio waves [6].

RFID-related Applications

Ngai et al first described the design and development of RFID system in a conveyor-belt sushi restaurant [7], while Tzeng et al proposed a framework for evaluating the business value of RFID technology in healthcare [7]. Yen and Shiu reported that the largest RFID implementation in an academic library is in the University of Hong Kong Library, which includes more than 1.2 million items containing RFID tags [8]. Finally, the Ministry of Education published application scenarios for employing RFID-assisted campus security and student safety implementation plans in 2008 (Table 2) [9].

Table 2: RFID-assisted campus security and student safety implementation plans in 2008.

Necessary RFID application scenarios	Notification of student as he/she commutes to and from school, as well as the student's locations at school		
	Service of student temperature anomalies		
	Danger zone management		
Alternative RFID application scenarios	Management of student as he/she commutes to and from school	Activity amount management	Customised school lunch allocation system
	Student academic record management	Service of school visitors (e.g. parents) management	Evaluation of clean-up practices
	Security management of areas for the student to clean	Platform of child care	Loan system of school apparatus and equipment
	Management system of student emergency report	Field trip management system	Student book loan management and other
	Service of mobility inconvenience report	Service of vehicle access management	

RESEARCH METHOD

Questionnaire Design

Based on the overall objective, the present study referenced the SERVQUAL scale, which includes five dimensions: 1) tangibles; 2) reliability; 3) responsiveness; 4) assurance; and 5) empathy [10]. The Parental Satisfaction Survey of RFID-Assisted Campus Security Management was, thus, created to explore parental perceptions of RFID-assisted campus security management and to evaluate satisfaction levels with this particular service [11].

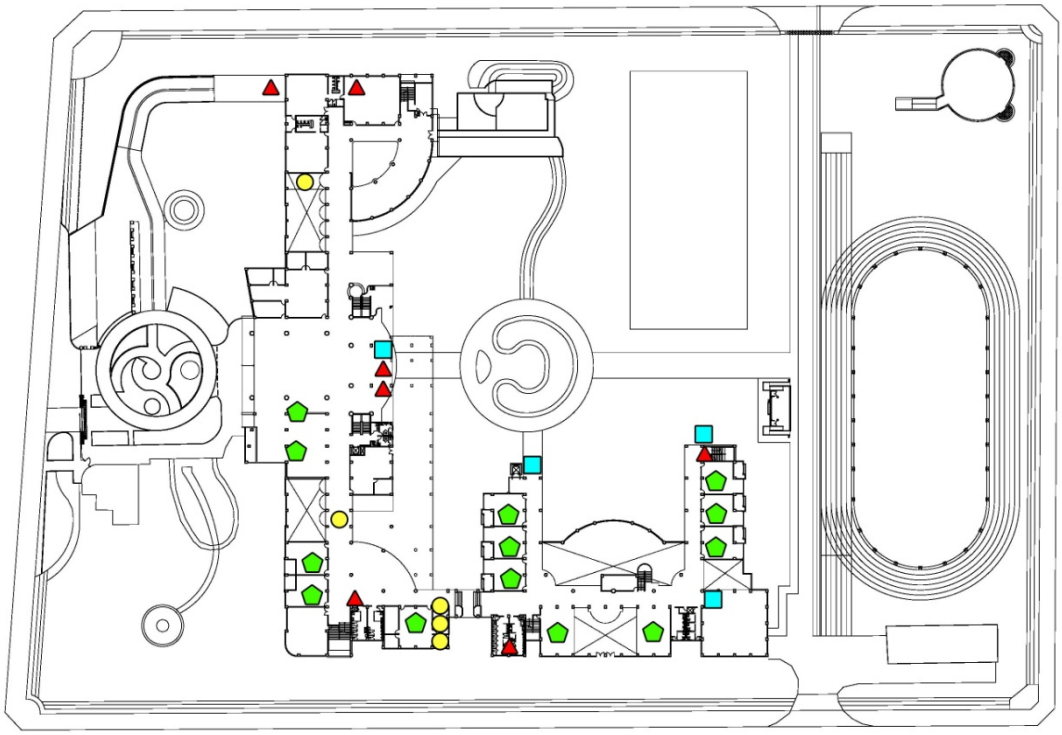
Participants

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Participants were 102 freshmen at the National Taichung Special Education School. The RFID campus security management programme was tested in the 2014. At that time, the students were primarily those suffering from moderate to severe mental retardation. Hence, their parents completed the questionnaires in order to provide sufficient answers. Of the 102 questionnaires distributed, 89 valid questionnaires were collected, yielding a response rate of 87.25%.

Developing the RFID Environment

Figure 1 shows the RFID environment established in this study. A total of 35 RFID readers were installed on campus in classrooms and major hallways, while 180 students wore wristband-type electronic tags. In terms of security planning, the campus was divided into four areas of supervision: 1) high-danger supervision: to determine if students cross into high-danger areas; 2) abnormal body temperature monitoring: to determine if students exhibit abnormal body temperatures; 3) school arrival/departure supervision: to monitor if students are entering/exiting the school grounds; and 4) campus visitor supervision: to determine if visitors enter or exit the school grounds. Overall, additional measures were taken to ensure student safety and campus security.



	Hazardous area administration area
	Abnormal temperature management area
	School and movement management
	Campus visitor management area

Figure 1: The RFID environment established in this study (RFID readers: 35 machines at classrooms and teaching areas; RFID wrist-electronic labels: 180 students).

Content Validity

To assess valid parental satisfaction levels as well eliminate or revise items that exhibit low levels of adequacy or discrimination, the first draft of the Parental Satisfaction Survey of RFID-Assisted Campus Security Management was examined by experts and practitioners in special education. The remaining items were factor analysed to derive the construct validity of the scale.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, proposed by Kaiser, was used to confirm whether the items were appropriate for factor analysis. The items of the pre-test questionnaire achieved a KMO value of 0.894, yielding favourable adequacy and validating that the items were appropriate for factor analysis.

Questionnaire Administration

The questionnaire that was developed comprised a five-point Likert scale, which was subsequently employed to perform item analysis and homogeneity tests. The item analysis involved evaluating the appropriateness of the items in the pilot test. In addition, the extreme group comparison approach, proposed by Kelly, was applied. The high-score group comprised the highest 27% of the pilot test scores, whereas the low-score group comprised the lowest 27%. A *t*-test was conducted to identify differences between group items. The significance of these differences was based on the mean of each item rated by the participants.

The obtained *t*-value achieved the level of significance. This *t*-value is also referred to as the critical ratio (CR), which is used to determine whether a difference is significant. A CR $\geqq$ 3.0 is considered acceptable [12], but to ensure a high level of discrimination among test items, only items that exhibited a CR $\geqq$ 3.5 ($p < 0.05$) were retained; the remaining items were eliminated.

The homogeneity test involved deriving the correlation coefficient of a single item and the total score. The items that exhibited correlation coefficients of less than 0.400 of the total score indicated a low level of homogeneity, and were deleted. According to the homogeneity test, the selected items in this study and the total survey score achieved the level of significance ($p < 0.05$).

Table 3: One-way ANOVA of parental education level and quality of service.

Quality of service		Quadratic sum	Degree of freedom	Mean of quadratic sum	F-value	*p*-value
Tangibles	Intergroup	1.219	2	0.610	1.733	0.183
	Intragroup	30.257	86	0.352		
	Total	31.477	88			
Reliability	Intergroup	1.004	2	0.502	1.440	0.243
	Intragroup	29.971	86	0.348		
	Total	30.974	88			
Responsiveness	Intergroup	3.953	2	1.977	4.589	0.013*
	Intragroup	37.040	86	0.431		
	Total	40.993	88			
Assurance	Intergroup	1.550	2	0.775	2.209	0.116
	Intragroup	30.177	86	0.351		
	Total	31.728	88			
Empathy	Intergroup	1.630	2	0.815	2.372	0.099
	Intragroup	29.550	86	0.344		
	Total	31.180	88			

*$p = 0.013 < 0.05$

RESULTS

Questionnaire Analysis

After retrieving the final questionnaires, data process (using SPSS statistics software) was as follows: 1) the parental background and parental satisfaction variables were examined using descriptive statistical analysis, which included frequency distribution and percentage; 2) the tangibles, reliability, responsiveness, assurance, empathy and parental satisfaction dimensions underwent a descriptive statistical analysis for mean and standard deviation; 3) a one-way analysis of variance (ANOVA) was used to verify differences in scores between parental background variables (i.e. relationship with children, age, profession, level of education, monthly household income and district in which their children ride the school bus) with the tangibles, reliability, responsiveness, assurance, empathy and parental satisfaction dimensions. If a significant difference was identified, then, the Scheffé method was used for *post hoc* comparison; and 4) Pearson's product-moment correlation analysis was conducted to derive the correlation between the five dimensions of service quality (i.e. tangibles, reliability, responsiveness, assurance and empathy) and overall parental satisfaction.

Results of the Questionnaire

The KMO value of the items on the pilot survey was 0.894, and Bartlett's test of sphericity also attained a level of significance ($p = 0.000 < 0.001$). Therefore, the items were able to be factor analysed. The cumulative explained variation of the four factors was 76.103%, which meets the conditions for item variance. In this study, all of the CR values reached 5.754 or greater. In addition, the correlation coefficients between the items and the total score were significant ($p = 0.000 < 0.001$), all attaining values of 0.601 or greater. Hence, all items were retained for factor analysis.

This study was based on the service quality model proposed by Parasuraman et al and the actual perceptions of parents [10]. Of parental background attributes (i.e. relationship with children, age, profession, level of education, monthly household income and the district in which their children ride the school bus), only the level of education had a significant impact on the tangibles, reliability, responsiveness, assurance and empathy dimensions. The one-way ANOVA for the level of education and the dimensions of service quality (see Table 3) indicated that the level of education exerted no significant effect on tangibles, reliability, assurance or empathy. However, it significantly influenced responsiveness ($p = 0.013 < 0.05$). The responsiveness of service quality in RFID-assisted campus security management achieved a significant difference due to the parental level of education. Thus, the Scheffé method (see Table 4) was employed, yielding a significant difference ($p < 0.05$).

Table 4: The comparison of the parental level of education and responsiveness via the Scheffé method.

Quality of service	(I) Level of education	(J) Level of education	Average deviation (I - J)	Standard error	*p*-value
Responsiveness	College degree or higher	Junior high school diploma or lower	-0.54041*	0.19506	0.025
		Vocational or high school diploma	-0.49279*	0.18145	0.029

*$p < 0.05$

Table 4 shows that, compared with parents who earned vocational or high school diplomas, junior high school diplomas or lower levels of education, parents who earned college degrees or higher were less satisfied with the responsiveness of the service quality. This indicates that a high level of parental education correlates with a low level of satisfaction with responsiveness and that parents with low levels of education felt more satisfied with responsiveness compared with those with high levels of education.

Table 5: The comparison of the dimensions of service quality and overall parental satisfaction.

		Tangibles	Reliability	Responsiveness	Assurance	Empathy
Overall parental satisfaction	Pearson's correlation coefficient	0.922***	0.914***	0.900***	0.967***	0.928***
	p-value (two-tailed)	0.000	0.000	0.000	0.000	0.000

*** $p < 0.001$

Table 5 lists the different analyses for the dimensions of service quality regarding RFID-assisted campus security management and overall parental satisfaction. In this study, all of the Pearson values were $\geqq 0.900$ (*** $p < 0.001$), indicating a high correlation between the dimensions of service quality and parental satisfaction.

SUMMARY OF RESULTS

The current status of the five dimensions of service quality regarding RFID-assisted campus security management is as follows: 1) parental satisfaction was the highest for tangibles and the lowest for responsiveness of service quality; and 2) parents with different ages and professions rated similar levels of satisfaction for the five dimensions of service quality. However, their levels of education were negatively correlated with satisfaction in the responsiveness dimension.

The overall parental satisfaction with RFID-assisted campus security management was as follows: 1) the five dimensions of service quality and overall parental satisfaction were highly correlated; 2) overall parental satisfaction rate was nearly 90%; 3) parents of different ages, professions and levels of education had a similar parental satisfaction with RFID-assisted campus security management.

FINAL REMARKS

This study examined parental satisfaction with RFID-assisted campus security management and promote the establishment of a safe environment for students at special schools. The survey results indicated that parental satisfaction was highly correlated with RFID-assisted campus security management. At the same time, a high level of parental education is correlated with a low level of satisfaction with responsiveness and that parents with low levels of education were more satisfied with responsiveness compared to parents with high levels of education.

Limitations

Despite the positive outcomes, there are several limitations to this study. Firstly, the special education schools wherein RFID was deployed to improve campus security included only the National Taichung Special School, the National Chiai Special School and the Affiliated Hearing Impaired School of the National University of Tainan. Secondly, this study only suggests applying RFID to the 9th grade levels in special schools to establish a safe environment for students. Finally, special schools did not offer introductory RFID operational training to increase teachers' RFID technology skills and to enhance their service abilities.

Suggestions for Future Research

The authors have some suggestions for further studies of schools as follows: 1) RFID should be employed for all grade levels; 2) education authorities should continue providing full subsidies; 3) teachers must be trained in RFID information and technology to secure student safety, meeting the needs of special school students; and 4) the schools should employ a full encryption scheme for RFID systems, database operations and storage.

Also, the authors suggest the following developments take place: 1) combine tag and watch functions, because RFID systems should be integrated into the functions of watches in order to facilitate the ease of use and decrease the number of tags by equipping students with only one tag that possesses a time-telling function; 2) auto-display of body temperature-sensing accuracy, since the distance between the tag band and the student's wrists must be less than 0.2 mm; otherwise an error can occur for body temperature measurement. Conversely, when bands are too tight, they can leave traces on the students' wrists, requiring teacher assistance to adjust the bands; 3) the tags should be completely waterproof, so that students do not need to remove the tags when washing their hands or taking showers. Consequently, the tags would be easy to use and hard to lose; and 4) the radiation of the current RFID system meets the safe radiation standards of the World Health Organisation.

REFERENCES

1. American Association on Mental Retardation. Mental Retardation: Definition, Classification, and Systems of Support. Washington, DC. *American Association on Mental Retardation* (1992).
2. Amini, M., Otondo, R.F., Janz, B.D. and Pitts, M.G., Simulation modeling and analysis: a collateral application and exposition of RFID technology. *Production and Operations Manage.*, 16, **5**, 586-598 (2007).
3. Campus Security Report Center, Ministry of Education. Statistical Analysis and Report on Campus Incidents in 2009 (2009), 18 January 2013, https://csrc.edu.tw/FileManage.mvc/FrontDetail/195
4. Campus Security Report Center, Ministry of Education. Statistical Analysis and Report on Campus Incidents in 2011 (2011), 18 January 2013, https://csrc.edu.tw/FileManage.mvc/FrontDetail/293
5. Parasurman, A., Zeithaml, V.A. and Berry, L.L., Refinement and reassessment of the SERVQUAL scale. *J. of Retailing*, 67, **4**, 420-450 (1991).
6. Piramuthu, S., Protocols for RFID tag/reader authentication. *Decision Support Systems*, 43, **3**, 897-914 (2007).
7. Tzeng, S.F., Chen, W.H. and Pai, F.Y., Evaluating the business value of RFID: evidence from five case studies. *Internal J. of Production Economics*, 112, **2**, 601-613 (2008).
8. Yen, B. and Shiu, B., Making RFID work: the world's largest university library RFID implementation. University of Hong Kong, Product #:HKU866-PDF-ENG (2009).
9. Lin, X., RFID used in campus security (2011), 25 June 2012, https://www.gs1tw.org/twct/gs1w/download/0701.pdf
10. Parasurman, A., Zeithaml, V.A. and Berry, L.L., SERVQUAL: a multiple-item scale for measuring consumer perceptions of service quality. *J. of Retailing*, 64, **1**, 12-40 (1988).
11. National School Safety Center. America's Safe Schools Week (2011), 15 February 2011, https://www.schoolsafety.us/safe-schools-week
12. Xie, F., Zhao, Y. and Han, B., Analysis based on AHP of factors influencing co-operation between higher vocational colleges and enterprises. *World Trans. on Engng. and Technol. Educ.*, 12, **3**, 408-413 (2014).