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Technology readiness of medical students and the association of technology readiness with specialty interest

La réceptivité aux technologies des étudiants en médecine et le rapport entre cette réceptivité et leurs intérêts envers certaines spécialités

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Abstract

Background: Technology readiness (TR) is a construct which characterizes an individual's propensity to utilize new technology. Despite increased technology use in healthcare, limited data exists on medical student TR and the relation of TR with specialty interest. This study assesses the TR of 2nd year medical students and its association with specialty interest.

Methods: Respondents completed a survey assessing their most preferred specialty, specialty interests, and technology readiness using a 5-point Likert scale. Using Chi-square analysis, we examined the relation between demographics, TR, and specialty interest.

Results: This study obtained a 45.7% (n = 53/116) response rate demonstrating that 79.2% (n = 42/53) of students were "technology ready." Male students were more likely to be technology ready (95.2%, n = 20/21, vs 68.8%, n = 22/32, p = 0.02) when compared to female students. Technology ready students were associated with being more interested in "Technology-Focused" specialties compared to students who were not technology ready (88.5%, n = 23/26 vs 70.4%, n = 19/27, p = 0.104).

Conclusions: As a cohort, most medical students were technology ready. It is inconclusive if technology ready students are more likely to be interested in technology-focused specialties due to the limited sample size of this study, although with an increased sample size, an improved understanding on technology readiness and its potential impact on student specialty interest may be obtained. Furthermore, knowledge of TR may aid in developing targeted technology-based education programs and in improving remedial approaches for students who are less comfortable with new technology.

Résumé

Contexte : La réceptivité aux technologies (RT) renvoie à la tendance qu'a un individu à utiliser une nouvelle technologie. Malgré l'utilisation accrue des technologies dans le domaine des soins de santé, il existe peu de données sur la RT des étudiants en médecine et sur la relation entre cette réceptivité et leur intérêt envers les diverses spécialités. La présente étude évalue la RT des étudiants en médecine de 2e année et le rapport entre celle-ci et leur intérêt envers certaines spécialités.

Méthodes : Les répondants au sondage ont été interrogés sur leur spécialité préférée, sur leurs intérêts envers les diverses spécialités et sur leur réceptivité aux technologies. Leurs réponses ont été évaluées à l'aide d'une échelle de Likert à 5 points. En utilisant l'analyse du Chi carré, nous avons examiné la relation entre la démographie, la RT et les intérêts de spécialité.

Résultats : Cette étude a obtenu un taux de réponse de 45,7 % (n = 53/116), montrant que 79,2 % (n = 42/53) des étudiants sont prêts pour l'utilisation des technologies. Cette tendance est davantage présente chez les étudiants de sexe masculin (95,2 %, n = 20/21, comparé à 68,8 %, n = 22/32, p = 0,02 pour les étudiantes). Les étudiants qui sont réceptifs aux technologies ont plus tendance que leurs homologues qui le sont moins à s'intéresser aux spécialités « axées sur la technologie » (88,5 %, n = 23/26, comparé à 70,4 %, n = 19/27, p = 0,104).

Conclusions : La plupart des étudiants de la cohorte étudiée étaient réceptifs aux technologies. En raison de la taille limitée de l'échantillon de l'étude, on ne peut pas conclure que les étudiants qui sont réceptifs aux technologies sont plus susceptibles de s'intéresser aux spécialités axées sur la technologie. Des recherches fondées sur un échantillon élargi nous aideraient à mieux comprendre la réceptivité aux technologies et son impact potentiel sur les intérêts des étudiants envers les diverses spécialités. De surcroît, ces connaissances peuvent contribuer à l'élaboration de programmes d'enseignement axés sur la technologie et de mesures d'aide au profit des étudiants qui sont moins à l'aise avec les nouvelles technologies.

Introduction

Healthcare is faced with rapid technological development due to the broad application of technology to areas such as electronic health records, medical informatics, medical and surgical devices, and mobile-based patient monitoring systems.[1-4] Along with the time-consuming processes involved with approval for these healthcare applications, there are often delays in implementing health technologies due to physician attitudes and beliefs about the use of technology in practice.[5-9] Furthermore, during undergraduate medical training, experiences with technology can influence the future adoption of technology into practice.[10-12] Despite this fact, medical students are neither explicitly trained in the use of electronic health information systems nor gain experience with medical or surgical device development during their pre-clerkship years, which increases the stress and difficulty associated with adopting technology in clerkship.[10,13] Therefore, it is important to investigate medical students' perspectives about technology use in healthcare before they enter clerkship and begin working in a clinical setting.

Technology readiness (TR) is a concept developed to characterize an individual's propensity to adopt and utilize new technology.[14] TR is constituted by four components which are measured through a Technology Readiness Index (TRI). The four components include two "Contributors" (1) *Optimism* and (2) *Innovativeness*, and two "Inhibitors" (3) *Discomfort* and (4) *Insecurity* (Figure 1).[14] The use of TR in healthcare has recently been shown to effectively predict a participant's inclination towards utilizing new technologies in their life and workplace.[15-20] Notably, applications of TR in healthcare have shown improved acceptance in mobile electronic record systems and advances in information and communication technology by healthcare workers.[16,18] Despite the effectiveness of TR on characterizing the propensity of individuals to adopt new technology, there remains a paucity of studies addressing the TR of medical students.[15,17] Because medical student TR may influence clinical experiences in clerkship and future technology adoption, it is valuable to determine the level of medical student TR prior to clerkship in order to identify students at need and improve TR.[10,19] Furthermore, there are gaps in the literature on the association of TR with medical student specialty interest, which may have implications for potential technology-focused remedial programs to eliminate any barriers associated with technology discomfort.[21,22]

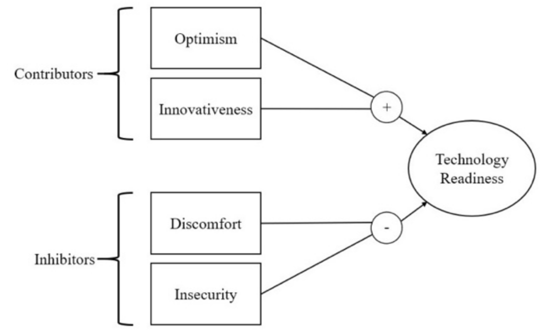

Figure 1. Relationship of contributing and inhibiting components of technology readiness index

The primary objective of this study was to analyze the TR of 2nd year (pre-clerkship) medical students. The secondary objective of this study was to determine whether students with positive TR scores were more likely to be interested in medical or surgical specialties, or specialties which may be seen as more technology-focused. The objectives of this study are relevant for informing undergraduate medical education programs that may wish to improve TR or remedy potential inadequacies associated with technology use for students entering clerkship.[23,24]

Methods

After the research ethics board approved this study (Nova Scotia Health Authority Research Ethics Board; File No. 1023087), we distributed an anonymous cross-sectional survey to 2nd year medical students at Dalhousie University, Nova Scotia, Canada using *Opinio* (Object Plant, Oslo, Norway). We distributed this survey together with a survey about the Pre-Clerkship Residency Exploration Program (PREP) - a 2-week elective program at Dalhousie Medical School designed to aid career exploration and planning while easing the transition to clerkship.

Survey structure

The survey contained questions pertaining to the demographic data of students such as age, gender, education, and rural/urban upbringing. Using the survey, we then assessed the current student interest in various medical and surgical specialties using questions on a 5-point Likert scale. Students then completed the modified-TRI for healthcare settings (Appendix A).[15] Although the modified-TRI is a validated survey, survey elements pertaining to demographics and specialty interests are not validated and are based on previous studies assessing student interest from the perspective of career planning.[25]

Technology Readiness Index (TRI) for healthcare settings

The survey incorporated a healthcare-focused modified-TRI which was developed to assess health professional's attitudes toward technology, technology readiness, and the propensity of medical students to adopt new technologies, as described by Caison et al.[15] Modifications implemented by Caison et al. included changing the wording of some instrument items to focus on the general healthcare setting rather than a consumer setting.[15] We adopted these modifications directly for this study. TR variables were defined as *Optimism*, *Innovativeness*, *Insecurity*, and *Discomfort* and students assessed the associated TRI items using a 5-point Likert scale.

Statistical methods and data analysis

We exported survey data into IBM Statistical Package for the Social Sciences (SPSS) software (version 25) and operationalized the TRI subscales of *Optimism*, *Innovativeness*, *Insecurity*, and *Discomfort* as weighted means of the associated TRI questions.[14] We calculated a mean total TR score by subtracting the technology readiness "Inhibitor" values (*Insecurity* and *Discomfort*) from the TR "Contributor" values (*Optimism* and *Innovativeness*).[14,15] For the resultant mean total TR scores, a positive TR score indicated that students are "Technology Ready" and a negative TR score indicated "Non-Technology Ready" students. Technology ready students, as determined by the TRI, are more likely to adopt new technology and accept new technology into their home and workplaces, whereas non-technology ready students associate technology with higher levels of discomfort and insecurity and are less likely to adopt the use of new technology.[14,15] It is noted that technology readiness, as a construct, is not a direct measure of aptitude or skill, but rather reflects a participant's attitude and inclination towards technology.[14] We calculated the internal reliability for each of the TRI subscales using the Cronbach's Alpha coefficient of internal reliability.[26]

To analyze the relationships between demographic characteristics, TR scores, TR subscales, and specialty interests we used Chi-square analysis with *post-hoc* Bonferroni correction applied for determining significance. We applied a 95% confidence interval and set the significance threshold at $p = 0.05$.

Technology readiness and specialty interest

To examine for associations between TR and medical student specialty interest, we analyzed the TR of students with respect to two distinct groupings. The first grouping was medical vs surgical specialties, where a medical and surgical specialty was defined in accordance with the Canadian Residency Matching Service (CaRMS) distinction and published literature.[27] This grouping was used as it commonly aligns with literature focused on career interest in early medical students.[28] Additionally, this grouping was used as it serves as a common initial decision point in career planning for pre-clerkship medical students at our institution and is similar to the *Career in Medicine Algorithm* published by the Stanford School of Medicine which is used for aiding students with career planning.[29]

The second grouping analyzed in this study was "Technology-Focused" vs "Non-Technology-Focused" specialties. This grouping was investigated to determine if students with positive TR scores were associated with having increased interest in specialties which feature more prevalent and varied applications of technology. To determine which specialties should be included as technology-focused specialties, the authors collaboratively created a list of factors which would define a technology-focused specialty. The main factors that were considered included: acquisition, use, and manipulation of medical imaging technologies, use of medical devices (such as implants and prosthetics), use of laser-based medical devices, use of endoscopy, use of robotics, and frequent use of hydromechanical systems (such as peristaltic or infusion pumps). These factors were chosen as they are applications of technology which deviated from the standard utilization of technology in healthcare (e.g. electronic health record systems, standard measurement devices). Sorting of the specialties was then performed independently by the authors and was followed by a collaborative review and any potential disagreements were resolved by consensus. Technology-focused specialties included: Anesthesiology, Radiation Oncology, Emergency Medicine, Internal Medicine, Radiology, Cardiac Surgery, Orthopedic Surgery, Otolaryngology, Obstetrics-Gynecology, Neurosurgery, and Urology. Non-technology-focused specialties included: Dermatology, Family Medicine, General Surgery, Neurology, Pediatrics, Plastic Surgery, and Psychiatry. From the available literature examining this topic, the grouping established was consistent with other studies.[30-32] For analysis, we considered students to be interested in a technology-focused or non-technology-focused specialty based on their reported primary specialty interest.

Results

Demographics

With a response rate of 45.7% *(n* = 53/116), 60.4% (*n* = 32/53) of students identified as female. We found that 50.9% (*n* = 27/53) of respondents were between the ages of 20-24 years, with 69.8% (*n* = 37/53) of respondents having a bachelor's degree as their highest level of education (Table 1). The majority of respondents indicated that they were raised in an urban community (86.8%, *n* = 46/53) and 86.8% (*n* = 46/53) of respondents preferred that their future practice location remain in an urban location. Respondents primarily noted that they intended to work in a hospital-based community practice as a future physician (39.6%, *n* = 21/53), while 32.1% (*n* = 17/53) preferred an academic centre.

Table 1: Demographic characteristics of respondents

Demographics (*N = 53*)		Frequency	Percentage (%)
Gender	Male	21	39.6
	Female	32	60.4
Age	20-24	27	50.9
	25-26	15	28.3
	27-28	8	15.1
	29-30	2	3.77
	>31	1	1.89
Education	Bachelor's	37	69.8
	Master's	15	28.3
	PhD	1	1.89
Career Interest	Medicine	39	73.6
	Surgery	14	26.4
Upbringing	Urban	46	86.8
	Rural	7	13.2
Desired Practice Location	Urban Community	46	86.8
	Rural Community	7	13.2
Desired Practice Setting	Community: Non-Hospital-Based	13	24.5
	Community: Hospital-Based	21	39.6
	Academic Centre	17	32.1
	Other	2	3.8

Technology readiness index: internal reliability

We determined that internal reliability of the TRI was acceptable as Cronbach's Alpha scores for the TR subscales of *Optimism* (α = 0.77), *Innovation* (α = 0.73), and *Discomfort* (α = 0.83) were > 0.70.[26] The Overall TRI (α = 0.67) and TR subscale of *Insecurity* (α = 0.63) was < 0.70. Although this value is approaching the threshold, studies have shown that Cronbach's Alpha scores > 0.50 are appropriate for scales with less than five items, as in the case of overall TRI (four items evaluated).[33-35] As the subscale of *Insecurity* lies between these thresholds (six items evaluated), this is an acceptable value for satisfying internal reliability of the instrument.[33,35]

Technology readiness

The majority of students (79.2%, *n* = 42/53) had positive TR values indicating that they are technology ready. Gender was found to be a significant factor associated with TR scales with 95.2% (*n* = 20/21) of male respondents having positive TR values compared to 68.8% (*n* = 22/32) of female respondents (*p* = 0.020). Other demographic factors were not found to significantly affect TR values. When we analyzed TR subscales, there was no difference in overall TR by age category, although we found that participants aged >27 years (*n* = 11/53) had greater *Optimism* subscales (3.71/5.00 ± 0.386) compared to participants < 27 years (3.41/5.00 ± 0.439, *n* = 42/53, *p* = 0.036). This age was chosen as it was a categorical variable which aligned with the average age of medical students who began medical school at a non-traditional age, as defined in the literature as age 25 to 30 years.[36-38] Additionally, male students had greater *Innovation* subscales (3.50/5.00 ± 0.448, *n* = 21/53) when compared to female students (2.91/5.00 ± 0.49, *n* = 32/53, *p* = 0.025).

Association of technology readiness on specialty interest

When analyzing student interest in medical or surgical specialities, we found that respondents interested in surgical specialities were more likely to have positive TR scores compared to respondents interested in medical specialties, although this finding did not reach statistical significance (85.7%, *n* = 12/14, vs. 76.9%, *n* = 30/39, *p* = 0.486). See Figure 2.

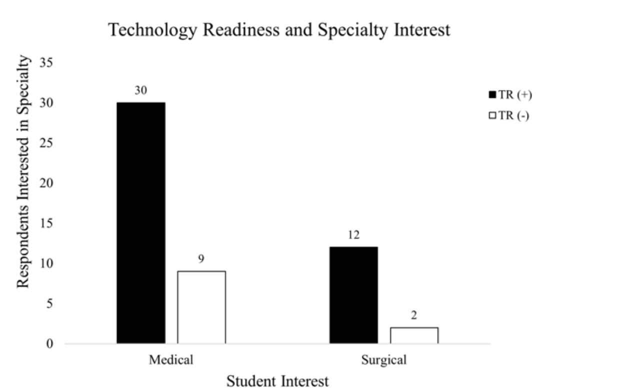

Figure 2. Overview of student technology readiness based on interest in medical or surgical specialities

When we analyzed student interest in technology-focused vs non-technology-focused specialties, we discovered that there was an association between respondents with positive TR scores being interested in specialties that were technology-focused compared to non-technology-focused specialties although this finding was not statistically significant (88.5%, n = 23/26, vs 70.4%, n = 19/27, p = 0.104). See Figure 3.

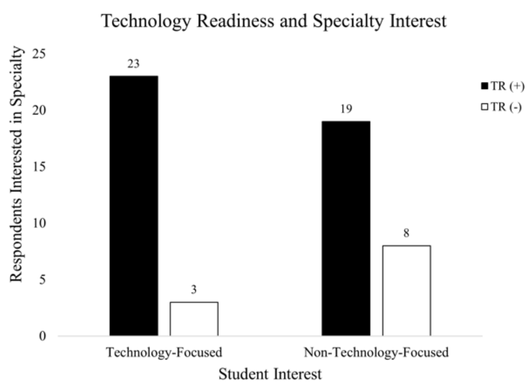

Figure 3. Overview of student technology readiness based on interest in technology-focused specialities

Discussion

Technology use in healthcare is increasing in prevalence with greater emphasis on technology use in the clinical learning environment.[3] With these trends, there is a need to ensure students are comfortable with technology in order to support medical students as they transition from clerkship into residency and their medical practice.[13,24,39] With the increasing reliance on technology, there is also a greater potential for technology use to impact career decisions. As student experiences and opinions of technology can impact future practice habits, it is useful to assess how medical students work with and view technology during their medical training.

The TRI serves as one of the most established tools to assess technology comfort and propensity to embrace new technology, although its application in the healthcare environment is limited.[15-20] Most studies utilizing TRI in healthcare, have focused on nursing staff and attending physicians, with a paucity of literature on medical student TR.[15,17] Here we present a study investigating TR of medical students and the association between TR and student specialty interest.[21,22] We hope that the results from this study can be used to optimize clinical education initiatives to better prepare students for clerkship while also improving TR and eliminating technology as a potential barrier in career selection.

In our study, we found gender to have important implications on TR. Contrary to previously published literature on TR in medical fields, age did not play a significant role when investigating TR or specialty interest.[15,17] This variation may be due to the recency of this study and the relatively young cohort, compared to other published studies, demonstrating more ubiquitous use and acceptance of technology. This is supported by our finding of increased participant TR when compared to a previous study by Caison et al. (79.2%, n = 42/53 vs 59.6%, n = 28/47).[15] Although cohort TR was increased, there remained a discrepancy between genders with 95.2% (n = 20/21) of males and 68.8% (n = 22/32) of females reporting that they were technology ready. This TR gap may have implications in future adoption of new technologies and comfort using medical technology and serves to identify a student group which may benefit from technology integration in pre-clerkship preparation programs and throughout clerkship. Additionally, although some medical students may be inherently inclined to prefer human-to-human interactions in their practice compared to increased technology use, improved comfort with technology can be seen as an asset for all students due to the ever-increasing use of technology in all specialties. By implementing technology-focused education programs during medical school, there is potential to proactively remedy the TR gap to improve student comfort with technology and remove barriers in pursuing specialties which may be perceived as technology-focused.[40,41] Proactive remediation-based programs implemented for the health professions in this proposed nature have been shown to narrow or eliminate potential gaps between students.[40-42] Additionally, if student TR improves from increased medical education program efforts, then future adoption of medical technology may be improved among physicians, with implications on patient care.[10,43]

The TR of medical students was also examined to determine if technology ready students were more likely to be interested in medical or surgical specialties, and if TR played a role with student interest in technology-focused specialities. Technology ready respondents were more likely to be interested in technology-focused and surgical specialties. This finding did not obtain statistical significance, possibly because of the limited sample size for analyzing sub-groups in this study.

This study assessed TR of medical students and the association between TR and specialty interest, using a validated model. Despite the rigorous nature of our analysis, our study has some limitations. We distributed this survey in association with PREP: an elective program which provides additional medical experiences for students while aiming to improve preparation for clerkship. Due to this medical focus, the results of this study may not accurately represent surgically inclined students. Despite this potential limitation, the medical (73.6%, n = 39/53) and surgical (24.4%, n = 14/53) career interest of the participants in the study is similar to the composition of the CaRMS 5-year average for Canadian medical graduate application trends which indicates a 82.4% medical interest and 17.6% surgical interest.[44] Additionally, although this study received a reasonable number of total respondents for analyzing aggregate values for TR, the reduction in number of respondents when analyzing specific subgroups limits the power required to support some of our conclusions. From this, an increased sample size is required to fully determine the relationship between TR and student interest in technology-focused and medical/surgical specialties. Moreover, an inherent limitation exists with respect to grouping technology-focused specialties for analysis. As there is no current technology-based classification for grouping specialties established in the literature, we developed an approach to grouping specialties based on their inclusion of technology. Although our grouping aligned with previous studies, the classification may not be completely accurate.[30-32] Although this study focuses on pre-clerkship medical students at the time when medical students often start making career decisions based on interests, there is potential that students may perceive specialties as having considerable technological components which may not be true. Furthermore, while specialty interest and TR are related at the pre-clerkship level, this trend may change throughout clerkship training and specialty interest may not lead to the eventual application to the specialty. To address this limitation, future studies should look at TR of medical students at the end of the first year of clerkship to analyze any changes in these findings after medical students have had greater clinical exposures. Lastly, we administered this survey at only one medical school, at a single timepoint. Although a reasonable response rate was achieved, the overall sample size limits the generalizability of the results to larger populations or those in different geographical locations.

Conclusion

With ever increasing use of technology in healthcare, technology readiness will continue to play a crucial role in ensuring medical student success. This study determined that medical students have a high technology readiness, despite age, although gaps between genders still exist. Aside from influencing student propensity to embrace new health technology, we also found that technology readiness may be associated with specialty interest. Results from this study can be used to improve medical education approaches focused on technology use in clinical environments and can provide insight into how TR may be linked to specialty interest. More research is certainly required to verify and expand our knowledge of this area.

Conflicts of Interest: The authors declare that there is no conflict of interest related to this study.
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Appendix A

Survey Instrument and Modified Technology Readiness Index

Demographics

What gender do you most closely identify with?

Male

Female

Prefer not to answer

Other: ______

What is your current age?

≤ 20 years

21-22 years

23-24 years

25-26 years

27-28 years

29-30 years

≥ 31 years

What is your highest level of education received prior to entering medical school?

Bachelor's

Masters

PhD

Other: ______

Do you consider yourself as an individual raised in an urban or rural community?

Rural (Population < 1000)

Urban (Population > 1000)

What is your desired practice location?

Rural Community

Urban Community

What is your desired practice setting?

Community: Non-Hospital-Based

Community: Hospital-Based

Academic Centre

Other: ______

Are you currently interested in a career in surgery or medicine?

Medicine

Surgery

Undecided

Specialty Interest

Please rate your current interest in the following specialties: (Likert Scale: 1 =Very Low, 2 = Low, 3 = Neutral, 4 = High, 5 = Very High)

Cardiac Surgery

General Surgery

Neurosurgery

Obstetrics-Gynecology

Orthopedic Surgery

Otolaryngology (ENT)

Plastic Surgery

Urology

Anesthesiology

Dermatology

Radiation Oncology

Internal Medicine

Neurology

Radiology

Psychology

Family Medicine

Emergency Medicine

Pediatrics

Please indicate your #1 Specialty Interest at the moment:

_________ (Free Text)

Please answer the following questions regarding technology use as it applies to your process of career planning:

(Likert Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

The potential for using new technology positively influences my interest in pursuing a medical specialty.

The potential for using new technology positively influences my interest in pursuing a surgical specialty.

I am more likely to pursue a specialty which involves the use of new technology.

Please answer the following questions based on how much you agree with the statements:

(Likert Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Modified – Technology Readiness Index

Subscale	
Optimism	*Technology gives people more control over their daily lives.* *New technologies are much more convenient to use.* *You find that technology designed to make life easier usually has disappointing results.* *You prefer to use the most advanced technology available.* *You like computer programs that allow you to tailor things to fit your own needs.* *Technology makes you more efficient in your occupation.* *You find new technologies to be mentally stimulating.* *Technology gives you more freedom of mobility.* *Learning about technology can be as rewarding as the technology itself.* *You feel confident that machines will follow with what you instructed them to do.*
Innovation	*Other people come to you for advice on new technology.* *It seems your friends are learning more about the newest technologies than you are.* *In general, you are among the first in your circle of friends to acquire new technology when it appears.* *You can usually figure out new technology without the help from others.* *You keep up with the latest technological developments in your areas of interest.* *You enjoy the challenge of figuring out new technology.* *You find you have fewer problems than other people in making technology work for you.* *You are always open to learning new and different technologies.* *There is no sense trying out new technology when what you have already is working fine.*
Discomfort	*Technical support lines are not helpful because they don't explain things in terms you understand.* *Sometimes you think that technology systems are not designed for use by ordinary people.* *There is no such thing as a technology manual that's written in plain language.* *When you get technical support, you sometimes feel as if you are being taken advantage of by someone who knows more than you do.* *You prefer to have the basic model of any technology rather than one with a lot of extra features.* *It is embarrassing when you have trouble with technology while people are watching.* *There should be caution in replacing important people-tasks with technology because new technology can breakdown or get disconnected.* *You get overwhelmed with how much you need to know to use the latest technology.* *The hassles of getting new technology to work for you usually makes it not worthwhile.* *Technology always seems to fail at the worst possible time.*
Insecurity	*You worry that information you send over the internet will be seen by other people.* *Any transaction/order you do/make electronically should be confirmed later with something in writing.* *Whenever something gets automated, you need to check carefully that the computer is not making mistakes.* *The human touch is very important when carrying out medical work.* *If you provide information via technology, you can never be sure it really gets to the right place.* *Technological innovations always seem to hurt a lot of people by making their skills obsolete.*