

eWPQ: DEVELOPMENT OF A COMPUTER-BASED WORK PERFORMANCE REVIEW APPLICATION FOR PERSONS WITH AUTISM SPECTRUM DISORDER

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RESUMEN

Las personas con *Trastorno del Espectro Autista (TEA)* enfrentan dificultades significativas para acceder al mercado laboral debido a sus síntomas. Pocas organizaciones cuentan con un ambiente preparado para emplear personas del espectro autista, que pudieran requerir apoyos específicos para ser productivos en su trabajo. Existen muy pocos instrumentos de evaluación vocacional, psicométrica o de desempeño laboral diseñados específicamente para empleados en el espectro autista. Aunque las personas en el espectro autista tengan talento para el uso de computadoras, la literatura sugiere que este uso ha sido restringido a aplicaciones terapéuticas o educativas, y no se identifican aplicaciones diseñadas para las necesidades laborales de las personas en el espectro autista. En el presente artículo, presentamos una aplicación computacional que implementa un instrumento de desempeño laboral especialmente diseñado para empleados en el espectro autista, con el objetivo de facilitar su uso por personas en el espectro autista y reunir rápidamente datos de desempeño para su evaluación y análisis.

Palabras Clave: autismo, computación, desempeño laboral.

ABSTRACT

People with *Autism Spectrum Disorder (ASD)* face significant difficulties accessing the job market due to their symptoms. Few organizations provide an appropriate environment to employ people on the autism spectrum who may require specific support to be productive at work. There are very few vocational, psychometric, or performance assessment instruments specifically designed for employees on the autism spectrum. Though persons on the autism spectrum may be talented for computer usage, the literature suggests this use has been restricted to therapeutic or educational applications, and no computer applications were identified as designed for work-related needs of people on the autism spectrum. In this paper, we present a computer application that implements a work performance instrument specifically designed for employees on the autism spectrum, with the objective to facilitate its usage by

people on the autism spectrum and swiftly gather performance data for evaluation and analysis.

Keywords: autism, computing, work performance.

1. INTRODUCTION

1.1. What is Autism?

Autism Spectrum Disorder (ASD) refers to a heterogeneous group of neurodevelopmental disorders characterized by deficits in social interaction and communication, and restricted, repetitive, and stereotyped behaviors and interests. *ASD* can present with or without an accompanying intellectual impairment, and may or may not be associated with medical or genetic conditions, or comorbid mental or other behavioral disorders. According to the most recent version of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)*, the level of severity can range from 1 to 3, with Level 1 requiring support, to Level 3 requiring very substantial support [1].

1.2. Computing for persons on the autism spectrum

There are two aspects of *ASD* that relate specifically to technology: the *autism advantage*, and their therapy and education.

The concept of *autism advantage* refers to individuals on the *autism spectrum* who demonstrate skills in attention to detail and tolerance for repetitive tasks, which are considered beneficial in technology fields [2]. Baron-Cohen et al. [3] indicate that individuals on the *autism spectrum* show talent “in recognizing repeating patterns in stimuli”, while suggesting a hyper-systemizing style of thinking (e.g., search for rules and consistency in stimuli) that reflects well on skills necessary in the technology sector (e.g., system analysis,

cyber security). This, combined with general preferences for knowledge entailing mechanical and non-social aspects of the world (e.g., physical systems, understanding the functioning of machines) [4], could place individuals on the *autism spectrum* who demonstrate these preferences and are able to develop the technical skills required to this field of study, as compelling candidates for success in the information technology sector.

The majority of computer software use associated on the *autism spectrum* is designed for educational and therapeutic purposes, and especially directed for children or students. Through a swift review of publications related to autism and computing topics on Google Scholar, **we could not identify software designed for adults, or related to employment.** This is consistent with a recent systematic review of employment in ASD [12].

1.3. Work perspectives for persons on the autism spectrum

People on the *autism spectrum* experience significant difficulties finding, and keeping, employment. As a group, they are characterized by exceptionally high levels of underemployment, unemployment, and malemployment (poorly matched work to skills). It is estimated that only 20% of people on the *autism spectrum* are engaged in the labor market, worldwide [5]. Different surveys in the United States and the United Kingdom also show similar trends, such as that 90% of the adults over 22 years old on the *autism spectrum* cannot obtain and maintain competitive employment, or that only 2% of the persons on the low end and 12% at the high end of the *autism spectrum* hold full time paid jobs [6].

Employed people on the *autism spectrum* may benefit from the incorporation of supports from employers, such as for social communication difficulties [7], and from alternative interview and selection processes. Specific factors that have been identified to support employees on the *autism spectrum* at work include:

- Support from the organization
- Supportive leadership and management
- Environmental modifications
- Development of strategies to facilitate coping and help to manage comorbid mental health conditions (such as anxiety and distress) [8]

Some of the challenges that are certainly faced can include:

- Manage factors that prevent task completion
- Stress
- Time management
- Odd or idiosyncratic communication styles
- Executive function and planning
- Sustaining attention [8]

However, many of these challenges can be overcome with appropriate organizational support and policies that focus on factors including, for example, inclusive leadership [8]. Specific workplace strategies that help integrating people on the *autism spectrum* include:

- Provide notice of change
- Plan upcoming tasks
- Provide opportunities for breaks
- Minimize sensory overstimulation [8]

E.g., *DXC Technology* (formerly *Hewlett Packard Enterprises*) [9] pursues a successful case model aimed at increasing employment opportunities for people on the *autism spectrum* in Australia and worldwide. The *Dandelion Program* offers employment to persons on the *autism spectrum* in technology related roles such as software testing, data analytics, and cyber security [10]. The vision of the project is to create a sustainable program that increases the workforce participation of persons on the *autism spectrum* with a three-year program focused on not only providing a job, but on building careers and skills that persons on the *autism spectrum* need to be successful in a competitive work environment; e.g., social development, staff integration, networking, and focus on certifications [11].

1.4. Work assessment for persons on the autism spectrum

As with any other employee, it is important to assess work performance in employees on the *autism spectrum*, to identify areas for improvement, and areas where the employee is performing well, to provide targeted and useful feedback that encourages self-improvement and positive reinforcement due to work done well. To date, there has been little research concerning the assessment of the work performance of employees on the *autism spectrum*, and very limited development of assessment tools that might be appropriate for use in this population [6].

The needs of the persons on the *autism spectrum* within a work environment are as unique as each individual and the specifics of their disorder. Having appropriate assessment tools to help understanding this individuality, and to potentially direct and monitor the effectiveness of interventions, employment, and performance objectives, can be particularly beneficial to this population [12].

A useful first step is addressing the vocational strengths and support needs that adults on the *autism spectrum* may present, at work. The *Autism Work Skills Questionnaire (AWSQ)*, is an instrument developed by Gal, Ben Meir and Katz [6] with this purpose. A separate study was performed to compare the instrument between persons on the *autism spectrum* and with no developmental disabilities [13]. Building upon the constructs identified through the construction and validation

of the *AWSQ*, a second instrument was subsequently developed to apply these constructs to assess the performance within the work environment — the *Work Performance Evaluation (WPE)* [14].

As for any person without a disability, it is necessary to measure the work performance of a person on the *autism spectrum*. The *WPE*, developed by Katz, Dejak and Gal [14], is a questionnaire developed to pursue such evaluation. The employee fills the form by him/herself, or completes the form as a structured interview, and a colleague or a superior of the employee on the *autism spectrum* fills another one. Each of the 31 items are answered on a 1 to 4 scale [14]. The aspects considered for *WPE* are:

- Work quality
- Inter-personal relationships with employer, colleagues, and clients
- Security
- Diligence
- Efficiency [14]

In another study concerning the *WPE*, Katz and colleagues [13] found stability of score change on the *WPE* over three time-points over 9 months. However, they noticed ceiling effects evident in the original tool, leading to a subsequent revision of the instrument, namely the *Work Performance Questionnaire* [15].

1.5. The Work Performance Questionnaire (WPQ)

The *Work Performance Questionnaire (WPQ)* is a currently used and soon-to-be-published work performance assessment instrument, specifically designed to evaluate the skills and abilities of the persons on the *autism spectrum* regarding their work environment performance. The *WPQ* considers 31 questions, split in five different sections, which evaluate how people on the *autism spectrum* perform in their tasks, and interacts with their work environment. The five sections are:

- Presentation
- Punctuality and Responsibility
- Task Comprehension and Planning
- Task Performance
- Dealing with Distractions
- Contact/Interaction with Colleagues and Superiors [15]

The questions are answered considering the levels of Frequency and Independence with which the behavior or action occurs. It is important to add comments, notes or recommendations concerning such behavior, to provide a deeper background and future direction about each trait.

The *WPQ* is meant to be filled similarly to the *WPE*: by both the employee with an *ASD* diagnosis, and their acting manager or supervisor. The evaluation exercise may consist

in meeting for an appraisal session, to compare the test results and find both opportunity areas in which the performance needs improvement, or provide commendation on good work performance [15].

2. THE ELECTRONIC WORK PERFORMANCE QUESTIONNAIRE (eWPQ)

2.1. The Electronic Work Performance Questionnaire (eWPQ)

The *Electronic Work Performance Questionnaire (eWPQ)* is the implementation of the *WPQ* as a computer program. Through it, the users can input their answers to the questionnaire, and save the data in plain text files, to ease the computer data input by analysts.

The application consists on a single screen with a series of tabs holding each of the different questions of the *WPQ*, so the user can answer them in a swift fashion. The users will add their personal information for identification, and then will navigate back and forth through the question tabs, answering the questions considering the level of Frequency and Independence with which the described behavior happened during the evaluated period.

After answering the questionnaire, the user will reach a Score Summary, which shows the scoring for each section.

Finally, the test takers will provide a simple analysis comparing their performance on the present questionnaire with the previous occasion that the questionnaire was filled, to establish if there has been a change on each section's performance, and explore the possible reasons of this change; e.g., in response to an intervention, or to addressing an area previously identified as requiring improvement.

The answers are stored in comma separated text files (CSV), to allow easy data analysis and reporting.

2.2. System Design

The requirements identified for developing the *eWPQ* application were:

1. The full questionnaire must be presented to the user in a simple, easy-to-understand, and easy-to-answer manner.
2. The screen design must be appropriate for persons both on and not on the *autism spectrum*.
3. The application may be used within secluded environments, and in organizations that are very aware of information security. It must be executed on a standalone computer, therefore not using network connectivity.

To fulfill these requirements, it was defined that:

1. The visual elements should be consistent throughout the application in both format and placement. All the required data input fields and other visual elements needed to answer each question, should have similar sizes, appearance, and be placed in the same, or in similar positions.
2. Hold a single question on each tab, to allow the test taker (especially if it is a person on the *autism spectrum*) to focus exclusively on such individual question.
3. The application may be used within secluded organizations, or similar situations.
4. The data must be stored in a transparent manner.
5. The application may need to be easily auditable by the organization.

2.3. System Development

eWPQ was programmed using the Java programming language version 1.8 [16], on the Eclipse Integrated Development Environment [17]. It heavily uses the Swing graphical library for the on-screen / visual components. Only one person developed the full system.

The development phase was performed with a **swift prototype-based approach**, to produce first a prototype application enabled with most functionalities. This prototype then entered a release and testing cycle. The development tasks would continue in parallel to the test. After the test was completed, the developer would add the test feedback received to the task list, which could provide new functionality requests or errors found.

To keep track of the characteristics being developed, and their implementation, we first created a general programming objectives task list to be tackled. The testing feedback would be added to the task list as received, and prioritized for development by considering the necessity of the given characteristic for the application, and the effort that the implementation would need, namely its attainability.

2.4. System Testing

eWPQ was developed and tested in conjunction with a group of software testers on the *autism spectrum*, who work as part of *DXC's Dandelion Program*, in Adelaide, South Australia.

The *Dandelion Program* members and the authors performed the tests. Three testers were on the *autism spectrum*, and three others were not. Considering that only one author developed the application, we have a 1 to 6 developer-to-testers ratio.

The tests consisted in using the prototype version on a full test case. The user would answer the test completely, take notes

on performance and any situations that may have arisen, and provide ideas about new functions.

The total indication items were 45; 60% of the indications came from people on the *autism spectrum*. 55.55% of the indications were tagged as Feedback, and 44.45% as Issues. 13% of the testing indications were discarded by been deemed not necessary for the application, or outside of the project scope. 42% were marked with an Easy to Fix difficulty to attain, and were fully completed during re-development, same as the 13% marked of Medium difficulty. 31% of the indications were considered Hard to Attain. 65% of these were completed, 7% were pushed backed for a later version of the application, and 13% were not completed due to time constraints.

2.5. System Usage

To execute the *eWPQ*, the user must use a computer with a Windows operating system and the Java Runtime Environment (JRE) version 1.8 or above installed (which can be downloaded freely from the Oracle website [16]). The Java language must be enabled by adding the proper environment variables [18].

The *eWPQ* JAR file should be placed on the user's desktop. Then, the user should create a directory or folder called "WPQ". The application uses this folder to place the data files used to save the questionnaire information. *eWPQ* checks that the folder is present on the user's desktop every time it starts. If the user forgets to create this folder, the application will automatically create it for him/her.

3. RESULTS

3.1. System Description.

eWPQ is a fully functional software application prototype that implements the *Work Performance Questionnaire* for persons on the *autism spectrum*. **The application takes the Work Performance Questionnaire answers as input, calculates the summary of the user answers, and finally stores all the questionnaire data into simple text comma-separated value files.**

The following is a walkthrough of the regular usage of the *eWPQ*:

1. The application consists on a single screen containing different visual components to input the information, held on individual and fully navigable tabs. The application was designed to provide a user experience similar to answering the paper questionnaire, with the advantage that the data input process is simplified and saved on the computer.

2. The users must input their personal data for identification and answer the different questions. Figure 1 shows the Personal Information tab, in which the user inputs identification data such as name, position, confirmation of who is filling the form, the workplace, and the time frame from the last test take. All the data answered, namely the personal information data, the question answers, and the summary, will be saved on the data files every time that the user clicks either on the Save or Navigation buttons.
3. The user will answer the individual questions considering the Frequency and Independence rating and the pertaining notes on the situation that the question relates to. This is done on the tab related to that specific question, shown in Figure 2. The implementation of this one-tab-one-question design was considered given that persons on the *autism spectrum* are characterized to have special situations with focusing on tasks, and might be easily distracted from the objective if they would have to answer different questions on the same tab. One question per tab will allow them to focus on the specific answer for a given question.
4. As the questionnaire is being completed and saved, the Score Summary is calculated and populated on the proper tab, shown in Figure 3. It will be updated on the event of any question update and save.
5. The user will answer five more questions, considering the test score changes between their previous evaluation and the present one, per section. An example is shown in Figure 4.
6. The data is saved on a single compressed zip file (an example of which is shown in Figure 5), containing all the responses to the questionnaire stored in the following files:
 - a. The Data file, containing the user identification data and the answers for the questions. Notes and Comparison questions are disregarded.
 - b. The Evaluation Improvement data files separated by Section.
 - c. The Full Data file, containing the user identification, the answers for each question, including the comparison questions. Notes are included.
 - d. The Note files for each of the questions.
 - e. The Summary file, with the questionnaire results in a single file with a textual approach. Meant to be a report to the management.

3.2. Study Limitations

The present article showcases the application developed for an ongoing study on work performance for people on the *autism spectrum*, though it could set ground for broader

studies concerning usage of computing to build specialized tools for people on the *autism spectrum*.

Validating the tool itself as a performance instrument is out of the scope of this study. Our purpose is to solely describe the development of the software tool, emphasizing the successful co-development of the electronic version with people on the *autism spectrum*.

4. CONCLUSIONS

With this project, we strive to bring opportunities for persons on the *autism spectrum* to evaluate (and be evaluated by) their work performance, using technology to design an application specific for their needs, and the needs of the organization.

This project demonstrates that it is possible to co-design and build computer applications that take into account the special needs of people on the *autism spectrum*, their feedback and user experience, similarly as with any software test performed by people not on the *autism spectrum*.

5. FUTURE WORK

The *WPQ* was first written in Hebrew, and then translated to English. Given the need to implement the *eWPQ* in Australia, the application was programmed considering the English language version of the questionnaire, though we have also considered translating the application to Hebrew and Spanish.

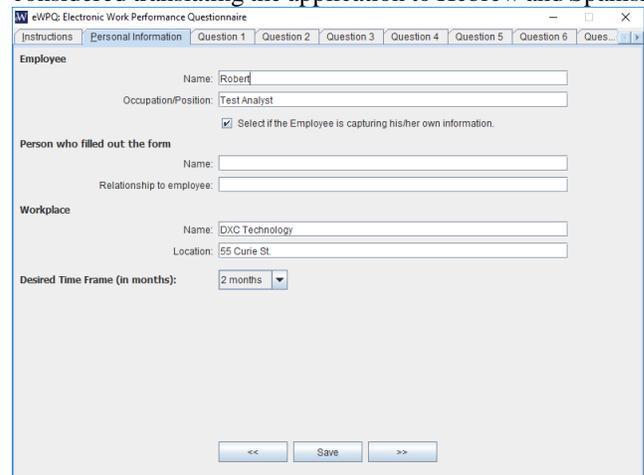


Figure 1. The *eWPQ* Personal Information tab. This information is used for user identification and file naming processes within *eWPQ*.

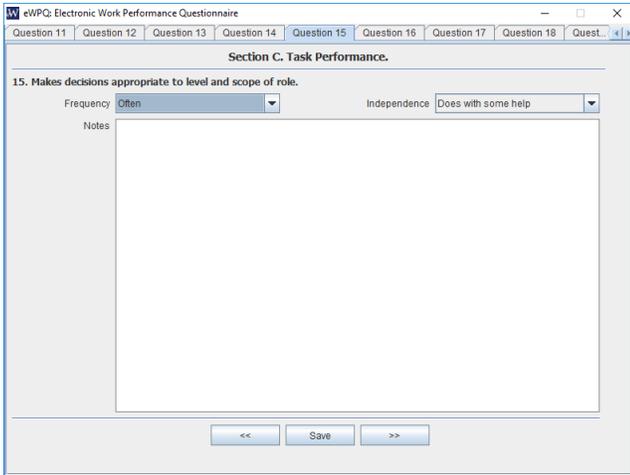


Figure 2. A question tab on *eWPQ*. These questions must be answered by indicating the Frequency and Independence rating with which the behavior occurred and giving detailed notes about the occurrences.

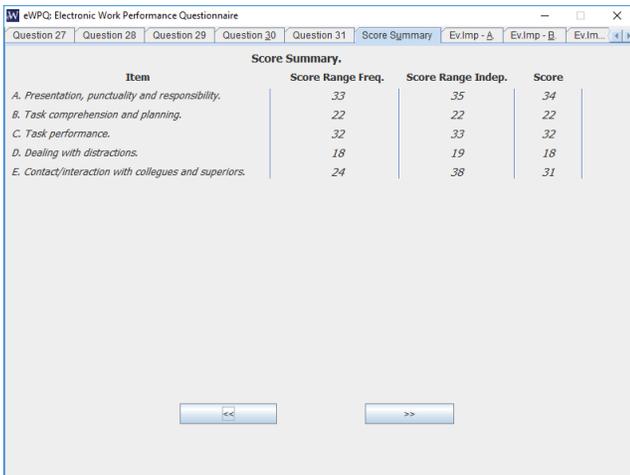


Figure 3. The *eWPQ* Score Summary tab will be updated every time the users update their answers.

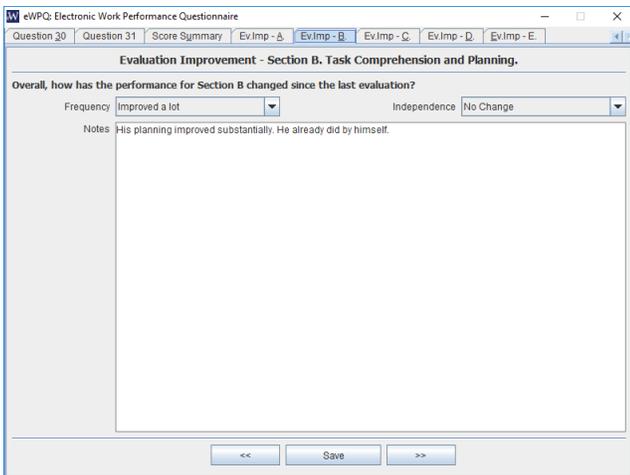


Figure 4. An example of a *eWPQ* evaluation improvement tab. These final questions must be answered also with the Frequency and Independence ratings, and proper notes.

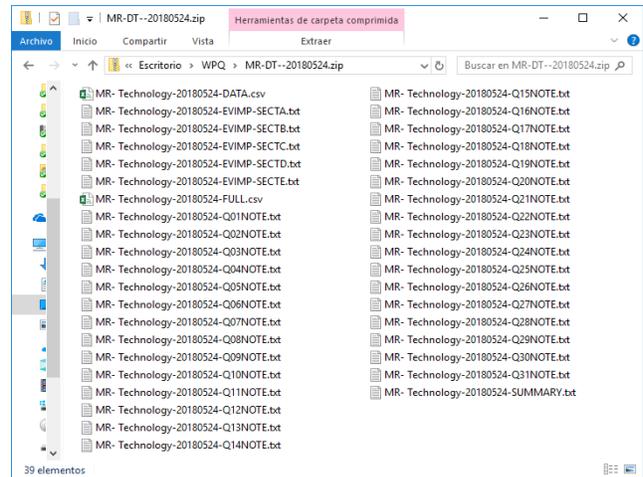


Figure 5. The contents of an example zip file holding all the questionnaire's answers.

The *eWPQ* is currently being implemented to measure the work performance of people on the *autism spectrum* in organizations. *DXC Technology*, home of the *Dandelion Program*, employs people on the *autism spectrum* as computer programs testers [10]. *DXC Technology* has begun using the *eWPQ*, with a full psychometric evaluation *eWPQ* underway.

For computer science, it could be of interest to assess if both versions of the *WPQ*, namely paper-based and computer-based, are valid and reliable. Given that the *eWPQ* was directly based on the *WPQ*, this would be expected to be affirmative. Furthermore, it could be worth studying the user experience for both options. And also, it would be worthy to explore the usability of software applications designed for people on the *autism spectrum*, and compare it to users not on the *autism spectrum*.

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7. REFERENCES

- [1] American Psychiatric Association (APA) (2013) Diagnostic and Statistical Manual of Mental Disorders. 5th ed. Washington, DC: APA.
- [2] Austin, R. D., & Pisano, G. P. (2017). Neurodiversity as a Competitive Advantage. *Harvard Business Review*, 1-9.
- [3] Baron-Cohen, S., Ashwin, E., Ashwin, C., Tavassoli, T., & Chakrabarti, B. (2009). Talent in autism: hyper-systemizing, hyper-attention to detail and sensory hypersensitivity. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1522), 1377-1383.
- [4] Baron-Cohen, S., & Wheelwright, S. (1999). 'Obsessions' in children with autism or Asperger syndrome: Content analysis in terms of core domains of cognition. *The British Journal of Psychiatry*, 175(5), 484-490.
- [5] United Nations Social Development Network (UNSDN) (2015, March). World Autism Awareness Day. Retrieved on <http://unsdn.org/2015/03/26/world-autism-awareness-day-2/>.
- [6] Gal, E., Meir, A. B., & Katz, N. (2013). Development and reliability of the autism work skills questionnaire (AWSQ). *American Journal of Occupational Therapy*, 67(1), e1-e5.
- [7] Hedley, D., Cai, R., Uljarević, M., Wilmot, M., Spoor, J., Richdale, A., Dissanayake, C. (2017). Transition to Work: Perspectives from the Autism Spectrum. *Autism*. Epub ahead of print. doi:10.1177/1362361316687697.
- [8] Vogus, T. J. & Lounds Taylor, J. (2018). Flipping the script: Bringing an organizational perspective to the study of Autism at work. *Autism*. Epub ahead of print. Doi: 10.1177/1362361318776103.
- [9] DXC Technology (2018). Our history. Retrieved on http://www.dxc.technology/about_us/ds/140019-our_history.
- [10] Hedley, D., Wilmot, M., Spoor, J., & Dissanayake, C. (2017). Benefits of employing people with autism: The Dandelion Employment Program [Electronic version]. Melbourne, Australia: La Trobe University, School of Psychology and Public Health, Olga Tennison Autism Research Centre.
- [11] Fieldhouse, M. (2017). Implementing a neurodiversity program. Sydney, Australia: DXC Technology.
- [12] Hedley, D., Uljarević, M., Cameron, L., Halder, S., Richdale, A., Dissanayake, C. (2017). Employment programs and interventions targeting adults with Autism Spectrum Disorder: A systematic review of the literature. *Autism*, 21, 929-941.
- [13] Gal, E., Landes, E., & Katz, N. (2015). Work performance skills in adults with and without high functioning autism spectrum disorders (HFASD). *Research in Autism Spectrum Disorders*, 10, 71-77.
- [14] Katz N, Dejak I and Gal E (2015) Work performance evaluation and QoL of adults with high functioning autism spectrum disorders (HFASD). *Work* 51: 887-892.
- [15] Gal, E., Waisman Nitzan, M., Schreuer, N., Kats, N. Hedley, D., Uljarević, M., Spoor, J. and Masters, C. (Unpublished work in progress). Work Performance Questionnaire (WPQ).
- [16] Oracle. (2018). Java Runtime Environment. Retrieved from <https://www.java.com/en/download/win10.jsp>.
- [17] Eclipse IDE (2016). Eclipse Foundation.
- [18] Oracle. (2017). The Java Tutorials – PATH and CLASSPATH. Retrieved on <https://docs.oracle.com/javase/tutorial/essential/environment/paths.html>