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# Application of Educational Software Packages for MRP Data Processing

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**Abstract:** *In the context of modern higher education courses, the use of software packages and tools has become imperative, especially in professional and application-oriented subjects. On the other hand, the contemporary business environment expects young engineers to be innovative in their work, applying current methods, techniques, models, and software tools that contribute to more efficient management. This paper aims to highlight the potential application of various software packages in the domain of Material Requirements Planning (MRP) to enhance teaching in the fields of Industrial Engineering and Engineering Management. The paper focuses on processing MRP data using the software packages WinQSB and POM-QM for Windows. Through comparative analysis based on different criteria, a preference is given to one or the other software program. The results showed that WinQSB was preferred in seven out of ten criteria. However, the choice of which program to use is left to the user.*

**Keywords:** *engineering management science, educational software; MRP; WinQSB; POM-QM software*

## 1. INTRODUCTION

Curricula and course content need to be continuously innovated in line with labor market demands and the expected competencies of students. This includes, among other things, the introduction of new educational software packages that enable students to better understand real-world problems and solve them quickly and efficiently (see [1]). These tools provide students with the opportunity to test and understand how theories work in practice, thereby gaining valuable experience for their future work in the industry [1]. Additionally, interest in a particular course unit is significantly increased.

The importance of using software packages is highlighted by authors Ku et al. [2] in four papers that cover topics forming the modules of the Engineering Management Science course. The first paper addresses the use of software packages in delivering critical path networks; the second on the application of software packages in linear programming: distribution method and simplex method; the third on the utilization of software packages in delivering quality control and financial analysis: net present value and break-even analysis; the last one on the use of software packages in delivering simulation [2].

The pressure to introduce new educational software comes from many sources, including employers who require graduates with both generic and specific skills, students who expect to use technologies in their learning [3], and higher education institutions that aim to offer attractive study programs and course content. For this process to be successful, the higher education institution must continuously invest in training its teaching staff to enable them to effectively use new technologies in teaching.

For successful production planning and management, managers use various principles and techniques, and certainly, one of the key ones is Material Requirements Planning (MRP), which is studied in the courses of Industrial Engineering and Engineering Management. This fact is confirmed by authors stating that Material Requirements Planning (MRP) is a traditional topic in operations management and industrial engineering education [4].

In the teaching process, students first manually calculate MRP and then use one of the software packages. The course content usually does not specify which software is used.

This paper aims to highlight the possibility of applying different software packages in the domain of Material Requirements Planning (MRP) to enhance teaching.

In the second part of the paper, the theoretical foundations of the MRP concept will be presented, and software packages for MRP data processing will be highlighted. In this chapter, preference will be given to the software packages POM-QM for Windows and WinQSB, which are most suitable for educational purposes.

Through an illustrative example, in the third chapter, the use of the selected programs will be explained in detail, and their comparative analysis will be conducted.

The conclusion will be presented at the end of the paper.

## 2. MATERIAL REQUIREMENTS PLANNING

Material Requirements Planning (MRP) is a powerful tool that helps manufacturing organizations manage their materials, inventory, and production schedules.

MRP is a computer-based set of planning techniques that examines future needs for finished products in terms of the master production schedule. It uses this information, along with the bill of materials, inventory status data, and lead time information, to generate requirements for all subassemblies, components, and raw materials that constitute the finished product [5]. If properly implemented and used, it can help production managers plan capacity requirements, schedule production time [6] and calculate production start dates so that parts are available at inventory locations precisely when they are needed [7].

MRP is usually depicted as the opposite of the just-in-time concept. However, if production is order-based and input data is accurately determined, MRP can actually achieve the just-in-time principle by producing parts precisely when they are needed.

MRP emerged in the late 1960s but was popularized only in the mid-1970s [7]. There are five stages of MRP system evolution (Material Requirements Planning (MRP); Closed- loop MRP; Manufacturing Resource Planning (MRP II); Enterprise Resource Planning (ERP) and Enterprise Resource Planning Extended (ERP II) [6], that were based on the application of ICT equipment and adequate software solutions [8]. In all mentioned phases (modules), MRP occupies a central place.

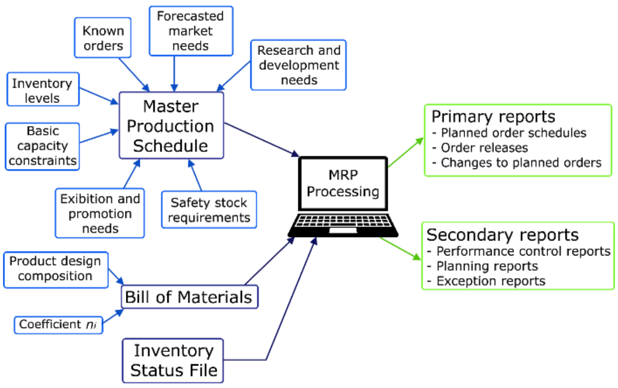



**Figure 1.** *MRP concept*

The MRP concept consists of several elements:

1. MRP inputs: Master Production Schedule (MPS); Bill of Materials (BOM) and Inventory Status File (ISF).
2. MRP software for calculating required orders.
3. MRP outputs: primary and secondary reports.

In Fig. 1, a schematic representation of the MRP concept is provided with input and output elements. Various authors (see [8] and [9]) present similar illustrations. In Fig. 1 the coefficient $n_i$ is the quantity of the *i*-th subassembly (production phase) incorporated into the first parent level.

When using the MRP system, it is assumed that the input elements are deterministic, which is not always the case in real business environments. Therefore, it is crucial to accurately determine these inputs before processing MRP data. To achieve this, students apply knowledge gained from various academic subjects.

The primary sources of uncertainty relate to the requested quantities (forecasting errors and calculation errors of planned quantities for individual parts that make up the complex product) and the estimation of lead times for individual production phases (material procurement, part manufacturing, assembly, and packing). Many authors emphasize the need to establish planned lead times. As Sadeghi et al. points out, the delivery time for each component is uncertain, leading to three states for each component: planned delivery time equals actual delivery time; planned delivery time is longer than actual delivery time; and planned delivery time is shorter than actual delivery time [5]. It is necessary to design times so that they are equal or approximately equal to the actual times. When designing, it is important to take into account all losses in the production cycle.

In their paper [10], the authors developed a mathematical model used for the optimization of planned lead times and periodicity for MRP systems under uncertain lead time. In [11] in the MRP planning system, each production activity (or production resource or supply chain stage) is assigned a planned lead time, and in [12] the production start dates for each station are calculated for each part backward scheduling using planned lead times.

### 2.1. Software packages for processing MRP data

The first computer programs that attempted to perform MRP calculations were produced in the late 1950s and early 1960s in the United States, at a time when business computing was in its infancy [5]. In today's world of digitalization, MRP modules can be part of a unified complex ERP system or part of software packages that solve problems in the broad area known as Decision Sciences, which students should use in the educational process.

Below are some software programs and tools that support MRP:

- MRP_Excel for Windows - free Manufacturing Resource Planning tool in an Excel workbook.
- Odoo - free online version for one app only, paid online version for all apps with free trial. Needed

app: Manufacturing, contains MRP, MES, PLM, Quality, Shop Floor and Maintenance.

- Officebooks - free for up to 5 users and up to 25 records.
- Axolt ERP - paid version with free trial for 14 days.
- Metasfresh ERP - open source ERP solution, self-hosted version is free.
- Quantitative Systems for Business (WinQBS) - free online version.
- Production and Operations Management (POM-QM) for Windows - free online version.

Considering the availability, costs of software usage, and the complexity of its implementation, it is best to use WinQSB and POM-QM software in the educational system. They can be used with any Production and Operations Management, Management Science, Quantitative Methods, or Operations Research textbook [13, 14, 15].

The suitability of the software for use depends on the modules being used and the subjective feeling of the software user. According to Amariei et al. [3], the use of WinQSB software in practice has a real contribution to the developed activities' efficiency, ensuring a high economy of time by eliminating routine activities tied to the classic way of solving the problem.

In [4] the evaluation results of three generations of students showed that WinQSB's MRP module is far more suitable software than POM-QM for Windows' MRP module and that the selected software was very useful in acquiring advanced MRP skills for students.

On the contrary, in the work [2], the authors emphasize that the more suitable software for solving the Critical Path method is POM-QM for Windows.

Various applications of different modules of both software can be found in the papers. In the work [3], the authors presented a way to solve certain types of problems using the WinQSB program. They used two modules, PERT/CPM and Facility Locations. In [16], the authors used the Queuing System Simulation module, in [17] they used submodules of Network Modeling to solve transportation problems, in paper [13] the PERT/CPM module was used, in [18] the Linear Programming module, and in [19] the Markov Process module of the WinQSB software.

The application of POM-QM software can be found in the work [20], where the authors defined a procedure for planning and scheduling consisting of formulating an equivalent linear programming problem and sequentially applying the software.

WinQSB includes 19 application modules: Linear programming (LP), Linear goal programming (GP) and integer linear goal programming (IGP), Quadratic programming (QP) and integer quadratic programming (IQP), Network modeling (NET), Nonlinear programming (NLP), Dynamic programming (DP), PERT/CPM, Queuing analysis (QA), Queuing system simulation (QSS), Inventory theory and systems (ITS), Forecasting (FC), Decision analysis (DA), Markov process (MKP), Quality control charts (QCC), Acceptance sampling analysis (ASA), Job scheduling (JOB), Aggregate planning (AP), Facility location and layout (FLL) and Material requirements planning (MRP) [15]. Some of the submenus of the main menu change its main available options, depending on the type of problem selected [13]. MRP module has the following capabilities [15]:

- Perform full MRP function with input including item master, bill of material (BOM), inventory records, and master production schedule (MPS)
- Explode the MPS requirements to obtain net requirements, planned orders and projected inventory for parts and materials
- Show indented, single-level, and where-used BOM
- Show graphic product structure
- Show MRP report in part item, ABC class, source type, or material type
- Show capacity analysis
- Show cost analysis.

POM-QM for Windows [14] is free software and it is a user-friendly Windows software [20]. It includes 29 modules or calculation methods. They are divided into three groups, Fig. 2. The modules in the first group typically are included in all POM and QM books, whereas the modules in the second group usually appear only in POM books, and the modules in the third group appear only in QM texts [14].

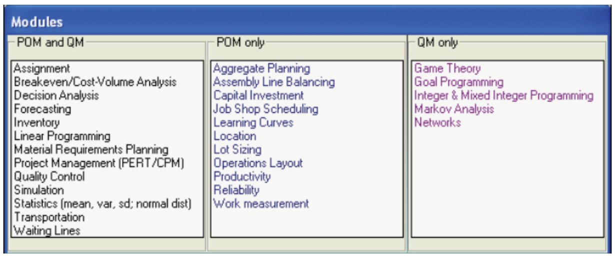



**Figure 2.** *POM-QM for Windows modules [14]*

## 3. ILLUSTRATIVE EXAMPLE

Design composition (decomposition scheme) is used to define and shape complex structures of products and is a basis for industrial product manufacturing. Within the framework of design composition a designer defines functional levels starting from elements that represent the first level, arriving at the final level, i.e., packed product, over sub-assemblies and assemblies [21]. The elements, sub-assemblies, assemblies, and packaged products are collectively called the production phase (PF).

Fig. 3 shows a design composition of a complex product (labelled as X) used as an example in several professional subjects in the field of Production Planning and Control in the basic vocational studies of Production Management.

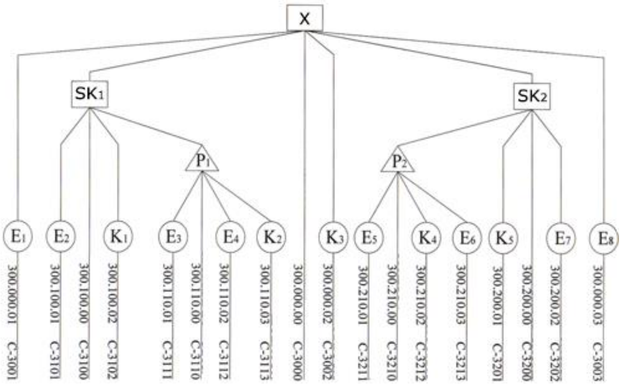



**Figure 3.** *Product design composition*

The product consists of four functional levels consisting of thirteen parts ($E_i$, $K_j$), two sub-assemblies ($P_k$), and two assemblies ($SK_l$), totaling 18 production phases (PF). Table 1 shows the values of coefficients $n_i$, i.e., the number of PFs incorporated into the first superior level, as well as the projected lead times PF ($T_i$). It is necessary to deliver 10,000 units of product X within 6 weeks. There are no stocks of individual production phases.

**Table 1.** *Coefficients $n_i$ and lead times per PFs*

| PF | $n_i$ | $T_i$ (week) |
|---|---|---|
| X | 1 | 1 |
| SK1 | 3 | 1 |
| SK2 | 1 | 2 |
| P1 | 2 | 1 |
| P2 | 1 | 2 |
| E1 | 0,2 | 3 |
| E2 | 2 | 2 |
| E3 | 3 | 1 |
| E4 | 2 | 2 |
| E5 | 0,025 | 2 |
| E6 | 6 | 2 |
| E7 | 1 | 1 |
| E8 | 0,02 | 1 |
| $K_i$, $i = \overline{1,5}$ | 1; 1; 3; 2; 4 | 1 |

Taking into account the defined input data, it is necessary to process them in one of the above-mentioned software packages and tools. In this work, POM-QM and WinQSB will be used. Detailed explanations on how to input data, descriptions of the main menu of the program, and obtaining solutions to the problem can be found for POM-QM for Windows in [14] and for WinQSB software in [15] and [13].

### 3.1. POM-QM for Windows

In the first step after launching the program, it is necessary to select the module in which you will be working. In this case, Material Requirement Planning is chosen. The next step involves creating a new problem where a window opens, and it is necessary to enter data in the initial menu (Fig. 4): Problem name; Total number of PFs that make up the complex product (Number of BOM lines – 18 pieces); Deadline for the completion of the complex product's production (Number of last period – 6 weeks).

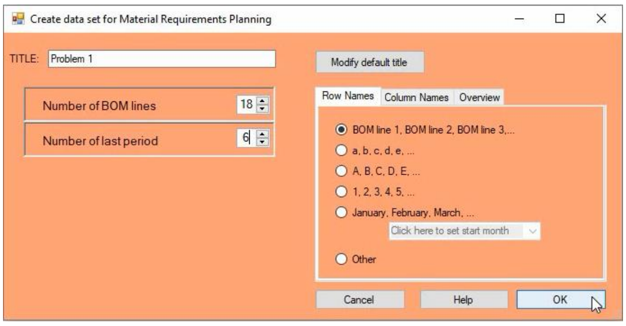
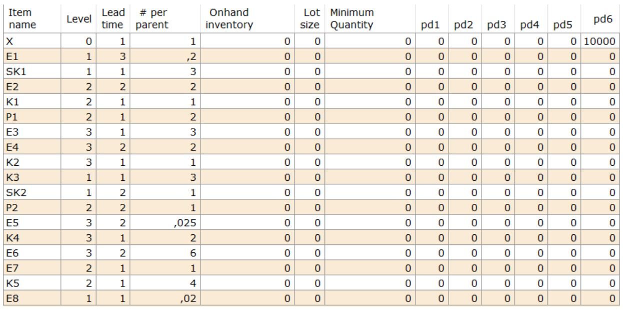



**Figure 4.** *Initial menu of POM-QM software*

After that, a table opens, Fig. 5, in which it is necessary to enter input data while considering the schedule of entering PFs. Subordinate PFs need to be entered after the parent PFs so that it is known that they are part of those PFs. For example, after SK1, it is necessary to enter P1, E2, and K1, see Fig. 3. In addition to the name/code of the PF, it is necessary to enter the level at which the part is located, lead time in weeks, coefficients $n_i$ (# per parent), and others.



| Item name | Level | Lead time | # per parent | Onhand inventory | Lot size | Minimum Quantity | pd1 | pd2 | pd3 | pd4 | pd5 | pd6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| X | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10000 |
| E1 | 1 | 3 | ,2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SK1 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| K1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P1 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E3 | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E4 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| K2 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| K3 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SK2 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| P2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E5 | 3 | 2 | ,025 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| K4 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E6 | 3 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E7 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| K5 | 2 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E8 | 1 | 1 | ,02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 5.** *Input data*

To the right of the table where the data is entered, a product tree is automatically generated (Fig. 6). It displays the levels, coefficient $n_i$, and lead time.

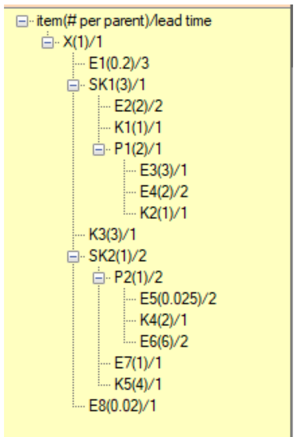



**Figure 6.** *Product tree*

To obtain a solution, it is necessary to select the Solutions option. Part of the solution is shown in Fig. 7 due to limited space in the document.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| X ( 0) | | | | | | | |
| Gross REQ. | | | | | | | 10000 |
| ON HAND | | | | | | | |
| SchdREC. | | | | | | | |
| NET REQ | | | | | | | 10000 |
| PlanREC | | | | | | | 10000 |
| ORD REL. | | | | | | 10000 | |
| E1 ( 1) | | | | | | | |
| Gross REQ. | | | | | | 2000 | |
| ON HAND | | | | | | | |
| SchdREC. | | | | | | | |
| NET REQ | | | | | | 2000 | |
| PlanREC | | | | | | 2000 | |
| ORD REL. | | | 2000 | | | | |
| SK1 ( 1) | | | | | | | |
| Gross REQ. | | | | | | 30000 | |
| ON HAND | | | | | | | |
| SchdREC. | | | | | | | |

**Figure 7.** *Part of the solution in POM-QM*

### 3.2. WinQSB software

After selecting the MRP module in WinQSB software, it is necessary to create a new problem, after which the initial menu opens, Fig 8.

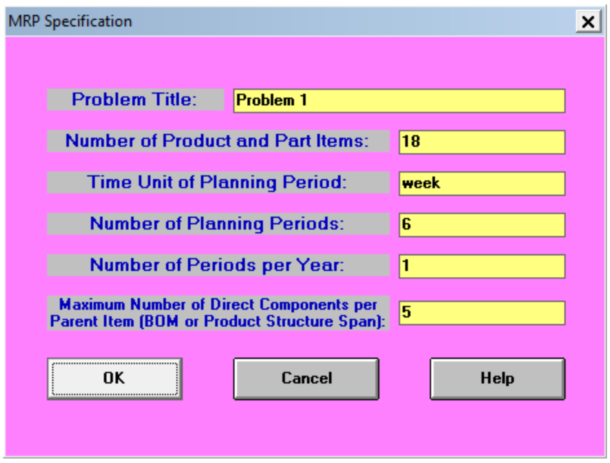



**Figure 8.** *Initial menu of WinQSB software*

In the initial menu, you need to enter the following information:

- Problem name.
- Total number of PFs (Product and Part Items) that make up the complex product (Number of Product and Part Items – 18 pieces).
- Time unit in which delivery times and lead times are expressed (Time Unit of Planning Period). The default unit is Month.
- Production completion deadline for the complex product (Number planning period – 6 weeks).
- Number of cycles per year (Number of Periods per Year).
- Maximum number of PFs that are installed in one assembly/subassembly/final assembly at the level of the complex product (Maximum Number of Direct Components per Parent Item – 5 pieces, see Fig. 3. Number of PFs for final assembly X is five).

After entering the required data, the Item Master table (Fig. 9) opens in the initial menu, where you need to enter several input data (part number/code, lead time, etc.).

| No | Item ID | ABC Class | Source Code | Material Type | Unit Measure | Lead Time |
|---|---|---|---|---|---|---|
| 1 | X | | | | Each | 1 |
| 2 | SK1 | | | | Each | 1 |
| 3 | SK2 | | | | Each | 2 |
| 4 | P1 | | | | Each | 1 |
| 5 | P2 | | | | Each | 2 |
| 6 | E1 | | | | Each | 3 |
| 7 | E2 | | | | Each | 2 |
| 8 | E3 | | | | Each | 1 |
| 9 | E4 | | | | Each | 2 |
| 10 | E5 | | | | Each | 2 |
| 11 | E6 | | | | Each | 2 |
| 12 | E7 | | | | Each | 1 |
| 13 | E8 | | | | Each | 1 |
| 14 | K1 | | | | Each | 1 |
| 15 | K2 | | | | Each | 1 |
| 16 | K3 | | | | Each | 1 |
| 17 | K4 | | | | Each | 1 |
| 18 | K5 | | | | Each | 1 |

**Figure 9.** *Part of the Item Master table*

To enter all input data, you need to select the View option and fill in the following tables:

- BOM (Bill of Material), as shown in Fig. 10. The data should be entered based on Fig. 3 and Tab. 1.
- MPS (Master Production Schedule). This table contains data on desired quantities of parts/products and the time required to complete production, as shown in Fig. 11.
- Inventory – contains information about parts inventory levels.
- Capacity – provides information on the maximum number of parts that can be produced within a specific period.

| Item ID | Component ID/Usage | Component ID/Usage | Component ID/Usage | Component ID/Usage | Component ID/Usage |
|---|---|---|---|---|---|
| X | E1/.2 | SK1/3 | K3/3 | SK2 | E8/.02 |
| SK1 | E2/2 | K1 | P1/2 | | |
| SK2 | P2 | E7 | K5/4 | | |
| P1 | E3/3 | E4/2 | K2 | | |
| P2 | E5/.025 | K4/2 | E6/6 | | |
| E1 | | | | | |
| E2 | | | | | |
| E3 | | | | | |
| E4 | | | | | |
| E5 | | | | | |
| E6 | | | | | |
| E7 | | | | | |
| E8 | | | | | |
| K1 | | | | | |
| K2 | | | | | |
| K3 | | | | | |
| K4 | | | | | |
| K5 | | | | | |

**Figure 10.** *BOM table*

| Item ID | Overdue Requirement | week 1 Requirement | week 2 Requirement | week 3 Requirement | week 4 Requirement | week 5 Requirement | week 6 Requirement |
|---|---|---|---|---|---|---|---|
| X | | | | | | | 10000 |
| SK1 | | | | | | | |
| SK2 | | | | | | | |
| P1 | | | | | | | |
| P2 | | | | | | | |
| E1 | | | | | | | |
| E2 | | | | | | | |
| E3 | | | | | | | |
| E4 | | | | | | | |
| E5 | | | | | | | |
| E6 | | | | | | | |
| E7 | | | | | | | |
| E8 | | | | | | | |
| K1 | | | | | | | |
| K2 | | | | | | | |
| K3 | | | | | | | |
| K4 | | | | | | | |
| K5 | | | | | | | |

**Figure 11.** *MPS Table*

After entering the input data, to solve the problem, you need to select the Solve > Explore Material

Requirements option and in the menu, as shown in Fig. 12, specify which report to display, as indicated in Fig. 13. Due to limited space, in Fig. 13, only a portion of the output report or results is displayed.

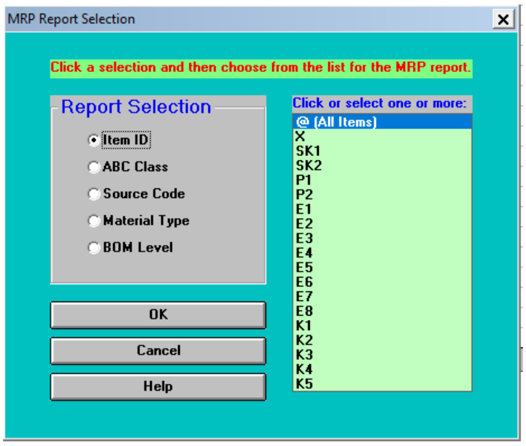



**Figure 12.** *MRP report selection*

| 06-03-2024 | Overdue | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Item: X | | LT = 1 | SS = 0 | LS = | UM = Each | ABC = | Source = | Type = |
| Gross Requirement | 0 | 0 | 0 | 0 | 0 | 0 | 10.000 | 10.000 |
| Scheduled Receipt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Projected On Hand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Projected Net Requirement | 0 | 0 | 0 | 0 | 0 | 0 | 10.000 | 10.000 |
| Planned Order Receipt | 0 | 0 | 0 | 0 | 0 | 0 | 10.000 | 10.000 |
| Planned Order Release | 0 | 0 | 0 | 0 | 0 | 10.000 | 0 | 10.000 |
| | | | | | | | | |
| Item: SK1 | | LT = 1 | SS = 0 | LS = | UM = Each | ABC = | Source = | Type = |
| Gross Requirement | 0 | 0 | 0 | 0 | 0 | 30.000 | 0 | 30.000 |
| Scheduled Receipt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Projected On Hand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Projected Net Requirement | 0 | 0 | 0 | 0 | 0 | 30.000 | 0 | 30.000 |
| Planned Order Receipt | 0 | 0 | 0 | 0 | 0 | 30.000 | 0 | 30.000 |
| Planned Order Release | 0 | 0 | 0 | 0 | 30.000 | 0 | 0 | 30.000 |
| | | | | | | | | |
| Item: SK2 | | LT = 2 | SS = 0 | LS = | UM = Each | ABC = | Source = | Type = |
| Gross Requirement | 0 | 0 | 0 | 0 | 0 | 10.000 | 0 | 10.000 |
| Scheduled Receipt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Projected On Hand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Projected Net Requirement | 0 | 0 | 0 | 0 | 0 | 10.000 | 0 | 10.000 |
| Planned Order Receipt | 0 | 0 | 0 | 0 | 0 | 10.000 | 0 | 10.000 |
| Planned Order Release | 0 | 0 | 0 | 10.000 | 0 | 0 | 0 | 10.000 |
| | | | | | | | | |
| Item: P1 | | LT = 1 | SS = 0 | LS = | UM = Each | ABC = | Source = | Type = |
| Gross Requirement | 0 | 0 | 0 | 0 | 60.000 | 0 | 0 | 60.000 |
| Scheduled Receipt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Projected On Hand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Projected Net Requirement | 0 | 0 | 0 | 0 | 60.000 | 0 | 0 | 60.000 |
| Planned Order Receipt | 0 | 0 | 0 | 0 | 60.000 | 0 | 0 | 60.000 |
| Planned Order Release | 0 | 0 | 0 | 60.000 | 0 | 0 | 0 | 60.000 |

**Figure 13.** *Part of MRP Report in WinQSB*

WinQSB provides several other reports in addition to the MRP report, including:

- Action (Order) List - which shows the week in which a specific part needs to be produced (Fig. 14).

| 06-03-2024 | Item ID | Overdue | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 | X | 0 | 0 | 0 | 0 | 0 | 10.000 | 0 | 10.000 |
| 2 | SK1 | 0 | 0 | 0 | 0 | 30.000 | 0 | 0 | 30.000 |
| 3 | SK2 | 0 | 0 | 0 | 10.000 | 0 | 0 | 0 | 10.000 |
| 4 | P1 | 0 | 0 | 0 | 60.000 | 0 | 0 | 0 | 60.000 |
| 5 | P2 | 0 | 10.000 | 0 | 0 | 0 | 0 | 0 | 10.000 |
| 6 | E1 | 0 | 0 | 2.000 | 0 | 0 | 0 | 0 | 2.000 |
| 7 | E2 | 0 | 0 | 60.000 | 0 | 0 | 0 | 0 | 60.000 |
| 8 | E3 | 0 | 0 | 180.000 | 0 | 0 | 0 | 0 | 180.000 |
| 9 | E4 | 0 | 120.000 | 0 | 0 | 0 | 0 | 0 | 120.000 |
| 10 | E5 | 250 | 0 | 0 | 0 | 0 | 0 | 0 | 250 |
| 11 | E6 | 60.000 | 0 | 0 | 0 | 0 | 0 | 0 | 60.000 |
| 12 | E7 | 0 | 0 | 10.000 | 0 | 0 | 0 | 0 | 10.000 |
| 13 | E8 | 0 | 0 | 0 | 0 | 200 | 0 | 0 | 200 |
| 14 | K1 | 0 | 0 | 0 | 30.000 | 0 | 0 | 0 | 30.000 |
| 15 | K2 | 0 | 0 | 60.000 | 0 | 0 | 0 | 0 | 60.000 |
| 16 | K3 | 0 | 0 | 0 | 0 | 30.000 | 0 | 0 | 30.000 |
| 17 | K4 | 20.000 | 0 | 0 | 0 | 0 | 0 | 0 | 20.000 |
| 18 | K5 | 0 | 0 | 40.000 | 0 | 0 | 0 | 0 | 40.000 |

**Figure 14.** *Show Action (Order) List*

- BOM (Bill of Materials) - selecting a part generates a report showing the quantity of sub-components that are part of its assembly. Fig. 15 displays the sub-levels for product X.

| 06-03-2024 | Item ID | Component ID | Component ID | Component ID | Usage |
|---|---|---|---|---|---|
| 1 | X | | | | 1 |
| 2 | | E1 | | | 0,20 |
| 3 | | SK1 | | | 3 |
| 4 | | | E2 | | 2 |
| 5 | | | K1 | | 1 |
| 6 | | | P1 | | 2 |
| 7 | | | | E3 | 3 |
| 8 | | | | E4 | 2 |
| 9 | | | | K2 | 1 |
| 10 | | K3 | | | 3 |
| 11 | | SK2 | | | 1 |
| 12 | | | P2 | | 1 |
| 13 | | | | E5 | 0,03 |
| 14 | | | | K4 | 2 |
| 15 | | | | E6 | 6 |
| 16 | | | E7 | | 1 |
| 17 | | | K5 | | 4 |
| 18 | | E8 | | | 0,02 |

**Figure 15.** *Show BOM*

- Product Structure in Graph – by selecting product X (Fig. 16), a graphical representation of the product's constructional composition shown in Fig. 17 is obtained.

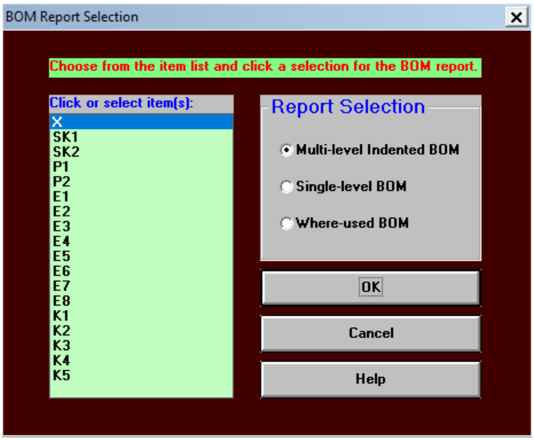



**Figure 16.** *Show Product Structure in Graph*

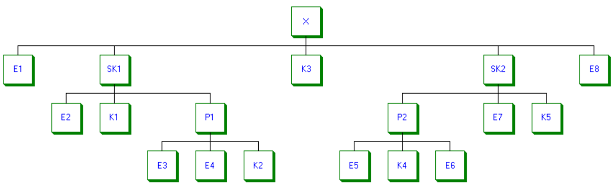



**Figure 17.** *Product design composition for X*

The software allows for the display of the constructional composition and other PFs. Fig. 18 and Fig. 19 show the constructional compositions of assembly SK1 and sub-assembly P1.

- Capacity Analysis.
- Cost Analysis.

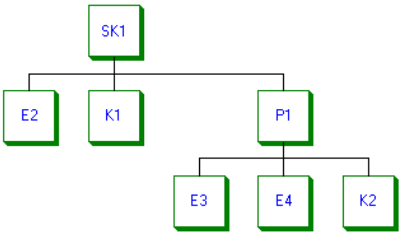



**Figure 18.** *Product design composition for SK1*

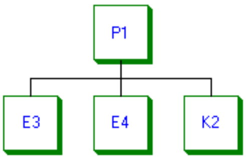



**Figure 19.** *Product design composition for P1*

### 3.3. Discussion

Both programs provide the capability to track multiple products. These tools are free and available to all users.

POM-QM is compatible with newer versions of Windows, and installing this program is easy. WinQSB is compatible with Windows Vista, but it can also be installed on newer versions. For this reason, installing WinQSB on newer versions is more complicated.

The difference between POM-QM and WinQSB is that in POM-QM, all modules are located in one place and visible under the MODULE option (see Fig. 2), whereas in WinQSB, there are main modules with submodules defined as Problem Types within the main module (see Fig. 20). For example, to solve a transportation problem in WinQSB, this option is found within the Network Modeling (NET) module, Fig. 21.

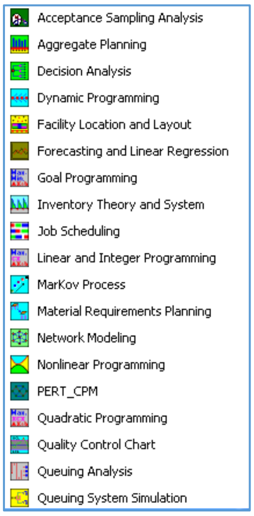



**Figure 20.** *WinQSB software moduls*

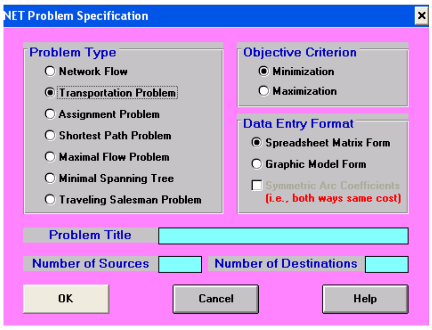



**Figure 21.** *Problem Type of the NET module*

Considering the processing of MRP data, their advantages, and disadvantages, a comparative analysis of both programs across ten features is presented in Tab. 2. It is clear from the table that WinQSB software is preferred in seven out of ten criteria compared to POM-QM for Windows.

**Table 2.** *Comparative analysis of POM-QM and WinQSB in terms of different features*

| **Characteristic** | **POM-QM** | **WinQSB** | **Preference (software)** |
|---|---|---|---|
| Interface layout | Nicer look, user-friendly | Rough look, less user-friendly | POM-QM |
| Number of parts | The number of parts is limited in range from 2 to 90 parts | The number of parts is not limited | WinQSB |
| Period of production | The period of production is limited (2-48 weeks) | The period of production is not limited | WinQSB |
| Modification of the production period | It's not possible to change production period | It's possible to change production period | WinQSB |
| Data entry | All data is entered in one table | Data is entered in multiple tables | POM-QM |
| Input sensitivity | When entering data, it is necessary to enter parts in certain order | When entering data, the order of parts is not important | WinQSB |
| Scrap | It does not take into account the scrap | It's possible to enter the amount of scraps in the table | WinQSB |
| Period od part production (time unit) | In weeks | Depends on the input data | WinQSB |
| Presentation of the product structure | In the form of a list | Graph. Possibility of displaying product tree for a certain parts | WinQSB |
| Visibility of modules and programs | All modules in one place | Modules and submodules (problem type) | POM-QM |

## 4. CONCLUSION

The application of educational software packages in subjects related to Industrial Engineering and Engineering Management is mandatory, regardless of the specific software package used. This approach enhances the quality of the teaching process and increases student interest in specific learning units.

For processing MRP data, using the example of a complex product, WinQSB and POM-QM software were utilized. A comparative analysis of the software across various features concluded that WinQSB is more suitable for use in seven out of ten criteria. However, the decision of which software to use should be left to the user.

It should be noted that the results will not be applicable in a real business environment if the input variables are not well defined. The study particularly emphasizes the importance of determining lead time, thus opening up a new topic for the application of different methods and software programs to calculate the projected lead time that will approximate the actual lead time.

## REFERENCES


[1] Fu, T. T. (2003). Applications of computer simulation in mechanism teaching. *Computer Applications in Engineering Education*, *11*(3), 156-165.

[2] Ku, H., Fulcher, R., & Xiang, W. (2011). Using computer software packages to enhance the teaching of engineering management science: Part 1—Critical path networks. *Computer Applications in Engineering Education*, *19*(1), 26-39.

[3] Amariei, O. I., Frunzaverde, D., Popovici, G., & Hamat, C. O. (2009). WinQSB simulation software – a tool for professional development. *Procedia-Social and Behavioral Sciences*, *1*(1), 2786-2790.

[4] Cvetić, B., & Ilić, O. R. (2015). Using educational software to enhance the teaching & learning in computer integrated manufacturing: Material requirements planning module. *Computer Applications in Engineering Education*, *23*(5), 682-693.

[5] Sadeghi, H., Makui, A., & Heydari, M. (2016). Multilevel production systems with dependent demand with uncertainty of lead times. *Mathematical Problems in Engineering*, *2016*(1).

[6] Najy, R. J. (2020). MRP (Material Requirement Planning) Applications in Industry—A review. *Journal of Business Manage*, *6*(1), 1-12.

[7] Thürer, M., Fernandes, N. O., & Stevenson, M. (2022). Production planning and control in multi-stage assembly systems: an assessment of Kanban, MRP, OPT (DBR) and DDMRP by simulation. *International Journal of Production Research*, *60*(3), 1036-1050.

[8] Mihajlović, I., Milijić, N. i Jovanović, A. (2016). *Upravljanje proizvodnjom*, Bor: Tehnički fakultet u Boru.

[9] Dametew, A. W., & Kitaw, D. (2017). Production planning and control for the comparative advantage of basic metal industry. *Global Journal of Researches in Engineering: A Mechanical and Mechanics Engineering*, *17*(3).

[10] Sadeghi, H., Makui, A., Heydari, M., & Ghapanchi, A. H. (2015). Proposing a model for optimising planned lead-times and periodicity in MRP systems under uncertainty. *International Journal of Services and Operations Management*, *21*(3), 310-331.

[11] Graves, S. C. (2022). How to think about planned lead times. *International Journal of Production Research*, *60*(1), 231-241.

[12] Thürer, M., Fernandes, N. O., Haeussler, S., & Stevenson, M. (2023). Dynamic planned lead times in production planning and control systems: does the lead time syndrome matter?. *International Journal of Production Research*, *61*(4), 1268-1282.

[13] Gurau, M. A., & Melnic, L. V. (2012). An overview of critical path applied to project management with WinQSB software. *International Journal of Mathematical Models and Methods in Applied Sciences*, *6*(7), 829-836.

[14] Weiss, H. J. (2016). *POM - QM for windows software for decision sciences: quantitative methods, production and operations management*, New York: Pearson Education.

[15] Chang, Y.L. & Desai, K. (2003), *WinQSB: software and manual. Version 2.0*, New York: John Wiley & Sons.

[16] Amariei, O. I., Dumitrescu, C. D., & Fourmaux, D. (2009). Analysis and behaviour understanding of a production system. *Analele Universitatii 'Eftimie Murgu'*, *16*(1).

[17] Amariei, O. I., Hamat, C., Coman, L., & Dumitrescu, C. D. (2011). Approaching modes of transport problems facilitated by the use of Winqsb software. *International Conference on Economics, Business and Management*, *2*(1), 20-24.

[18] Jovanovic, J. (2023). Solving the linear programming problem using software WINQSB. *In 2nd International Conference on Advances in Science and Technology*. Herceg Novi, Montenegro, 259-267.

[19] Andrei, G. M. (2012). Shaping the evolution of the company products market by applying markov chains method, *International Journal of Advances in Management and Economics*, *1*(5), 52-56.

[20] Sasidhar, B. (2023). Application of POM-QM for windows and multiple ARC network model for scheduling in a single-stage, multi-item compatible process. *Asian Journal of Advances in Research*, *6*(1), 523-538. Article number AJOAIR.2817

[21] Jovanovic, R. J., Milanovic, D. D., Adamovic, Ž. & Đukić, R. (2012). Models for describing the structure of product and projection of manufacturing cycle. *In 16th International research/expert Conference*, TMT 2012, Dubai, UAE.